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Understanding the size selectivity in diamond mesh codends based on flume tank experiments and fish morphology: effect of catch size and fish escape behaviour

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Report of the ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB)

6-10 May 2013

Bangkok, Thailand

International Council for the Exploration of the Sea

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Executive summary

The ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) met in Bangkok, Thailand from 6 to 10 May 2013 in a three-session mini-symposium and-to address four Terms of Reference. The main outcomes are detailed below.

Key Findings

Low Impact and Fuel Efficient Fishing (LIFE; Section 0)

- There is no single solution of increasing interest and uptake of new fishing gear by fishers, as it often depends on the fishery and individual circumstances
- Consideration should be given to incentivizing the participation of fishers and the development of incentive frameworks
- Fishers must be part of efforts to find solutions to problems facing their fishery
- Consideration should be given to how motivation and incentives (economic, regulatory, peer pressure, societal expectations, public perception, markets, etc.) can drive uptake and change by fishers
- WGFTFB should consider its role (if any in regard to the consideration of appropriate motives and incentives.

Use of artificial light as a stimulus on fish behavior in fish capture (LIGHT; Section 7.3)

- Why light fisheries are so popular in the east and less so in the west is not precisely clear but is probably linked to abundance and schooling behavior.
- Knowledge of why fish are positively phototactic is not well understood and remains an area of ongoing research
- Light fisheries are often less harmful to the environment and overfishing is seemingly less of an issue than in fisheries using other gear
- In some fisheries light can create conflict between fisheries or fishers and is difficult to regulate.

Selectivity of trawls in multispecies/crustacean fisheries (SHRIMP; Section 7.4)

- Despite many years of development, significant additional efforts are still required to optimize the performance of bycatch reduction devices in this fishery, and to overturn negative attitudes by fishers.
- The challenge to get fishers to use grids, let alone large ones, is difficult given their concerns for shrimp loss and impact of cumbersome grids on the fishing operation.
- The option of utilizing bycatch was seen as a somewhat attractive option that could provide additional income to fishers. However, warnings were raised regarding the sustainability of this activity and that this should not

be seen as a quick response to initial issues and concerns with TEDS or BRDs.

- The role of WGFTFB on the issue of "balanced fishing" was debated but there was no clear agreement on the next steps.

Innovative dynamic catch control devices in fishing (Section 0)

- A preliminary definition of dynamic catch controls was made: "Dynamic catch controls are systems that change the structure and functioning of the gear during the fishing operation so that the gear stops collecting fish when the desired amount of fish has been retained by the gear and actively release excess fish".
- The group identified the drivers for using dynamic catch controls. Some of the most relevant are: control of catch size; release of excessive catch without harm; keep fish alive for freshness; quality and pricing; safety.
- We defined the scope to specifically include only trawls, seines and purse-seines. In other than these gears the group did not identify need for dynamic catch control. The group agreed on not including separator trawl techniques (separator panels, separator ropes, eliminator trawl, etc.) as dynamic catch controls systems.

Future applications of artificial light in fishing gear design and operations (Section 9)

- The Topic Group should continue to work by correspondence in 2013/2014, with the aim of addressing the current terms of reference and presenting a draft report to the plenary session of ICES/FAO WGFTFB in 2014.

Relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries (Section 10)

The Topic Group will continue to work by correspondence in 2013/2014, with the aim of addressing the following items:

- Data collection of main characteristics of trawlnets used in different Mediterranean fisheries;
- Assessment of maximum dimensions and adequate rigging for trawl fishing gears.
- Empirical relationships among different parts of the fishing trawl gears, including different type of likely attachments, as well as between some of these parts and the otterboard size and the engine power of the vessel shall be reported.

1 Directive

The directive of the WGFTFB is to initiate and review investigations of scientists and technologists concerned with all aspects of the design, planning and testing of fishing gears used in abundance estimation, selective fishing gears for bycatch and discard reduction, as well as benign environmentally fishing gears and methods with reduced impact on the seabed and other non-target ecosystem components.

The Working Group's activities shall focus on all measurements and observations pertaining to both scientific and commercial fishing gears, design and statistical methods and operations including benthic impacts, vessels and behaviour of fish in relation to fishing operations. The Working Group shall provide advice on application of these techniques to aquatic ecologists, assessment biologists, fishery managers and industry.

2 Introduction

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Venue: Bangkok, Thailand

Date: 6–10 May 2013

3 Terms of Reference

The **International Council for the Exploration of the Sea** (ICES)/Food and Agriculture Organization of the United Nations (FAO) Working Group on Fishing Technology and Fish Behaviour (WGFTFB) chaired by: Michael Pol, USA; Petri Suuronen, FAO) met from 6–10 May 2013 in Bangkok, Thailand to work on the following terms of reference:

a) **Innovative dynamic catch control devices in fishing.** A WGFTFB topic group of experts will be formed in 2013 to investigate innovative dynamic catch control devices in fishing. Dynamic catch control systems are defined as catch control systems that change the structure and functioning of the gear during the fishing operation so that the gear stops collecting fish when desired amount of fish has entered the retention part of the gear, or actively releases excessive fish with least level of mortality. The group will have the following terms of reference:

- i) Review the fisheries, conditions, and impact on mortality where dynamic catch control can be an advantage and consider/share recent improvements towards commercial fisheries.
- ii) Provide improvements/solutions for the challenges related to excessive catches that are encountered in the different fisheries and gears worldwide.
- iii) Produce a report including a review of the status of knowledge and technology on the subject, with identification of technology gaps, and recommendations for future research on the technology for the different fisheries and fishing gears.

a) *Conveners: Eduardo Grimaldo (Norway), Mike Pol (USA), Pingguo He (USA).*

b) **Future applications of artificial light in fishing gear design and operations.** A WGFTFB topic group of experts will be formed in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions. Specifically the group aims to:

- i) Describe and summarize fish response to artificial light stimuli;
- ii) Describe and summarize use of artificial light in world fisheries;
- iii) Describe and tabulate different light sources to attract fish;
- iv) Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions;
- v) Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods.

Convener: Heui-chun An (Korea), Mike Breen (Norway), Yingqi. Zhou (China).

c) **Relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries.** A WGFTFB topic group of experts will be formed to investigate relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries. The group will have the following terms of reference:

i) To review technical specifications of trawl gears used in different fisheries (benthic, demersal and pelagic) with attention, in particular, to the dimensions of headline, footrope, circumference or perimeter at various levels of the net, extension piece, codend, otterboard, and other aspects;

ii) To model and describe relations between engine power and gear-size characteristics of European trawl fleets. Modelling engine power and different parts of the fishing gears as well as between some of these parts and the otter-board size should be investigated.

Convener: Antonello Sala (Italy).

4 Participants

A full list of participants is given in Annex 1. The agenda is included in Annex 2.

5 Explanatory note on meeting and report structure

The partnership of ICES and FAO in jointly sponsoring the Working Group began in the early 2000s. The 2013 meeting was hosted under a supporting agreement developed in an exchange of letters between FAO and ICES, formalized in 2011, in which it was agreed that FAO would host the meeting of the Working Group every third year in a location of FAO's designation, and the meeting would be organized as a mini-symposium. The 2013 meeting was the first held under this arrangement.

The first three days of the meeting were dedicated to a mini-symposium on Impacts of Fishing on the Environment, with each day devoted to an individual subject in a symposium format. The text in this report is copied from the FAO report on this meeting, authored by Steve Eayrs. For a fuller description of the mini-symposium, please see that document. The fourth and fifth days included an open session structured as a symposium, followed by meetings of topic groups as has been the practice of the WG since 2005.

Individual conveners were appointed for topic groups and the mini-symposium during prior meetings to oversee and facilitate work by correspondence throughout the year and at the meeting. The Chairs asked the conveners to prepare a working document, reviewing their progress on their ToRs and recommendations and conclusions based on the topic group's work. The **summaries and recommendations** for the working documents for each ToR were reviewed by WGFTFB and were accepted, rejected or modified accordingly to **reflect the views of the WGFTFB**. However, the contents of these working documents do not necessarily reflect the opinion of the WGFTFB. Some topic groups included small numbers of individual presentations based on specific research programmes related to that topic. The abstracts are included in this report, together with the authors' names and affiliations. Although discussion relating to the individual presentations was encouraged and some of the comments are included in the text of this report, the contents of the individual abstracts were NOT discussed fully by the group, and as such they **do not necessarily reflect the views of the WGFTFB**.

6 Opening of the meeting

The meeting was opened by greetings from the Chief and Deputy Chiefs of the Training Department of the Southeast Asian Fisheries Development Center (SEAFDEC, the venue for the meeting), Mr Chumarn Pongsri, and Mr Hajime Kawamura. Mr Hiroyuki Konuma, FAO Regional Representative for Asia and the Pacific, opened the meeting on behalf of FAO. Bundit Chokesanguan of SEAFDEC, and the co-chairs of the Working Group also made introductory remarks. The agenda and terms of reference and the appointment of Antonello Sala (CNR-ISMAR, Ancona, Italy) as rapporteur were reviewed and accepted by the group. A number of meeting details were conveyed to the WG.

7 Report from the Mini Symposium: Impacts of fishing on the environment

7.1 Mini-Symposium Goal and Objectives

The mini-symposium sought to provide significant input to the pursuance of three objectives:

The overarching goal of the symposium is to: (i) provide a forum for global synthesis of the scientific knowledge of fishing technology and its effective use; (ii) review and discuss advances in technology and analytical methods used to study or mitigate these effects; and (iii) provide a forum for discussion on how perceptions and decisions of fishers and resource managers affect the success of achieving sustainable use and successful management of fishery resources. The specific objectives are:

- To evaluate the role and potential for capture technologies and practices to reduce fishing impacts on the environment and energy use;
- To provide sound, credible, timely, peer-reviewed, and integrated scientific and technical advice on the use of capture technologies in support of effective fishery management and protection of the marine environment;
- To foster new partnerships between scientists and technologists from developed and developing economies to minimize the impact of fishing in the environment.

7.2 Report from Low Impact and Fuel Efficient Fishing Gear (LIFE) session

The LIFE session was convened by Thomas Catchpole (Cefas, UK), Yoshiki Matsushita (Nagasaki University, Japan), and Bob van Marlen (IMARES, Netherlands).

The primary focus of this session was:

- cost-effective next generation fishing technologies;
- modification/replacement of high-impact and fuel-hungry fishing techniques and practices;
- energy efficient fishing vessel design;
- barriers for adoption of LIFE fishing practices;
- policy and socio-economic aspects;
- research directions.

The LIFE session comprised a total of 15 presentations from 11 countries. The keynote presentation was presented by John Willy Valdemarsen (Institute of Marine Research, Norway) and Petri Suuronen (FAO) titled, *Low-Impact and Fuel Efficient (LIFE) fishing: challenges, opportunities, and some technical solutions*.

The scope of presentations in this session was broad and varied, and clearly indicated that a significant body of research and development is being dedicated to LIFE fishing around the world, including major advances across a variety of fishing gear types including fish and shrimp trawls, beam and pulse trawls, tuna longlines, cod pots, set-nets, and boat seines.

Most of the research presented in this session involved fishing gear modification and the collection of data at sea, however one presenter spoke of the value of computer simulation as a cost-effective alternative. One presenter spoke of advances in diesel electric technology that could be utilized in large fishing boats as a more efficient option that also produces significantly fewer carbon emissions, while another described the benefits and outcomes of vessel energy audits. Two presenters spoke of advances in set-net gear in Thailand and the exciting benefits that such gear brings to coastal communities, while several others spoke of the effect of large mesh panels and semi pelagic doors to reduce fuel consumption.

In at least four presentations in this session the problem of poor uptake of research outcomes by fishers was discussed. This was a central theme to two presentations where gear uptake was poor despite clearly identified and articulated benefits that could be realized from this uptake, extensive outreach efforts, and even financial subsidy to fishers. One presenter made a case for a return to first principles by accepting a need to better understand the motivation of fishers to change and how such change can be permanent. Another suggested that by applying recognized principles of change management it might be possible to guide fishers through the process of change so that they are better prepared adopt LIFE fishing practices.

During the discussion period of this session several other key points were made regarding LIFE fishing:

- There is no simple solution to increasing interest and uptake of new fishing gear by fishers, as it often depends on the fishery and individual circumstances
- Consideration should be given to incentivizing the participation of fishers and the development of incentive frameworks
- Fishers must be part of efforts to find solutions to problems facing their fishery
- Consideration should be given to how motivation and incentives (economic, regulatory, peer pressure, societal expectations, public perception, markets, etc.) can drive uptake and change by fishers
- WGFTFB should consider its role (if anything) in regard to the consideration of appropriate motives and incentives.

7.3 Use of artificial light as a stimulus on fish behavior in fish capture (LIGHT) session

The LIGHT session was convened by Mike Breen (IMR, Norway), Heui-Chun An (NFRDI, South Korea), and Professor Yingqi Zhou (Shanghai Ocean University, China).

The primary focus of this session was:

- physics and measurement of artificial light in water;
- design and engineering of artificial lights;
- promotion of energy efficient light sources;
- biology of vision;
- behavioural responses of fish to artificial light;
- application of artificial light in fisheries,
- novel and innovative approaches.

The LIGHT session was comprised of 16 presentations by presenters from 8 countries, and the majority of presentations focused on research conducted in Asia, and in particular Japan and Korea. The keynote presentation titled, *Fish behavior and visual physiology in the capture process of light fishing*, was presented by Professor Takafumi Arimoto (TUMST, Japan).

A clear message from several presenters was that the most significant technological advance in light fisheries in recent years is the adoption of LED lights in favor of incandescent, halogen, and metal halide illumination. This technology is similarly effective compared to many of the older sources of illumination with the added benefit of requiring considerably less energy; hence the consumption of fuel and greenhouse gas emissions is significantly reduced.

Many presenters focused on the use and development of artificial light in squid jigging operations, although other fishing methods that were discussed included purse-seine, angling, lift nets including the Bagan, large-scale fish traps (set-nets), and fish pots. The physics, properties, and characteristics of light were covered by several presenters including tools to measure light and clarification of the myriad units used in light measurement. Other presenters described the importance of understanding fish vision, its influence on fish response to visual stimuli, and research methods and techniques to investigate fish vision and function such as visual acuity, maximum sighting distance, and spectral sensitivity. One presenter spoke of the development and engineering of LED lights while another spoke of harvesting renewable energy sources from the fishing process and ocean environment itself using innovative technologies and techniques to develop self-powered underwater lights. Several presenters spoke of measurement of the underwater light field and the behavior of squid and fish in response to artificial illumination either onboard the fishing vessel or underwater, while another spoke of the importance of polarized light to some fish and invertebrates particularly in prey detection. The benefits of LED lights compared to other sources of illumination was covered by several presenters, including their effect on catch rates and fuel consumption, as well as the relative performance of LED lights of different color.

During the discussion period of this session several key points were made regarding LIFE fishing:

- Why light fisheries are so popular in the east and less so in the west is not precisely clear but is probably linked to abundance, schooling behavior
- Knowledge of why fish are positively phototactic is not well understood and remains an area of ongoing research
- Light fisheries are often less harmful to the environment and overfishing is seemingly less of an issue than in fisheries using other gear
- In some fisheries light can create conflict between fisheries or fishers and is difficult to regulate.

7.4 Selectivity of trawls in multispecies/crustacean fisheries (SHRIMP) session

The SHRIMP session was convened by Professor Pingguo He (UMASS, USA) and Bundit Chokesanguan (SEAFDEC).

The primary focus of this session was:

- species and size selectivity – new technologies and approaches;
- future of bycatch reduction in multispecies trawl fisheries;
- alternative fishing practices for tropical shrimp trawl fisheries;
- balanced harvest vs. selective fishing;
- social and market implications.

The SHRIMP session comprised 13 presentations representing research efforts from 11 countries. The keynote presentation was provided by David Brewer (CSRIO, Australia) titled, *Understanding and managing impact on bycatch in Australia's Northern Prawn Fishery*.

Many presenters focused on challenges associated with the development, testing, uptake, and regulatory compliance of turtle excluder devices (TEDs) and bycatch reduction devices (BRDs). Several presenters reported high shrimp to discard ratios and the ongoing practice of landing significant numbers of undersized fish for commercial purposes. Another issue raised was the loss of shrimp and other commercial species from using TEDs and BRDs. This loss was often described as the result of poor compliance with effective regulations and poor motivation by fishers to optimize performance, despite the associated risk of catch loss. In other instances, catch loss was reportedly due to poor TED or BRD design, or clogging of the TED by sawfish, tree limbs, and other debris. Overall, it seems that significant additional efforts are required in many fisheries to optimize the performance of these devices and overturn negative attitudes by fishers.

One presenter described efforts to deal with bycatch by turning it into fishmeal using onboard fish meat and bone separators, and the daily production that could be produced per hour. Another focused on the use of semi-pelagic doors and floating bridles to reduce herding behavior and capture of demersal bycatch species and the benefits such gear can bring in terms of reduced seabed impact and fuel consumption. This presenter also included details about the performance of a topless trawl to retain shrimp and allow the escape of bycatch, while another focused on codend modification and the impact this had on the minimum landing size of shrimp.

The value of underwater video cameras to observe crab behavior in response to an approaching trawl was described by one presenter, with a view of using this information to consider modifications to groundgear to reduce crab contact, damage, and mortality. Several other presenters focused on improving the selectivity of trawls for Norway lobster, while another focused on the benefits of being able to land both shrimp and Atlantic cod at the same time using a dual codend trawl.

Efforts by SEAFDEC to introduce the Juvenile and Trash Excluder Device (JTED) into shrimp fisheries in the region were presented, as was an outline of a new project focusing on mitigating bycatch in fisheries in the region, including the adoption of best fishing practices and use of landed catch. This is a regional projected funded by GEF and participating countries.

During the discussion session the issue of blocked or clogged grids was raised and options to overcome this issue was discussed. This often impacted the level of enthusiasm by fishers to use these devices because of associated shrimp loss. Ways to reduce this issue include the use of a well-designed and maintained grid operated at the correct angle. The use of a large grid was suggested as this increased the filtering area and increased the likelihood that shrimp could pass around the blockage and through the grid into the codend. A large grid also comes with a large escape opening so that large animals can quickly pass unimpeded through the opening and the distortion of the codend by a large grid helps ensure the escape cover is held over the escape opening by water pressure. Ensuring the escape cover can be readily pushed aside by escaping large animals and then readily returned to place (by water pressure) is also important. Despite these options the challenge to get fishers to use grids, let alone large ones, is difficult given their concerns for shrimp loss and grid impact on the fishing operation.

A concern was raised regarding the notion that a successful TED or BRD trial in one location or fishery could be quickly replicated in another. This was not always the case and time and patience was required to tune and optimize these devices, and this may take several weeks or longer.

The option of utilizing bycatch was seen as a somewhat attractive option that could provide additional income to fishers. However, warnings were raised regarding the sustainability of this activity and that this should not be seen as a quick response to initial issues and concerns with TEDS or BRDs. Alternative tools to managing bycatch should also be considered, such as incentives to fishers in regions were a lack of capacity prevents enforcement of legislation. The possibility of getting producers and suppliers involved to produce incentives was discussed.

The issue of 'balanced' fishing was also raised. This is using fishing gear or modifying fishing operations so that species of all sizes are retained and utilized rather than discarded dead or dying. It was argued that balanced fishing was more in keeping with the ecosystem approach to fisheries rather that the use of fishing gear that selects for a limited number of species. The role of WGFTFB in this issue was debated but there was no clear agreement on the next steps.

8 FTFB Open session

8.1 Oral presentations

8.1.1 Understanding the size selectivity in diamond mesh codends based on flume tank experiments and fish morphology: effect of catch size and fish escape behaviour

Junita D. Karlsen, DTU Aqua; Ludvig Ahm Krag, DTU Aqua; Bent Herrmann, SINTEF; Kurt Hansen, SINTEF

This study quantifies potential size selection of a fish and a crustacean species in diamond mesh codends during a fishing process. Changes in mesh geometry along the codends and at different catch weights were recorded in a flume tank and subsequently used together with the morphology of cod (*Gadus morhua*) and Nephrops (*N. norvegicus*) to simulate potential size selection. By assuming certain patterns of fish escape behaviour in the codend, it was demonstrated that it was possible to replicate results for size selection based on sea trials with similar codends. Results show that L50 can increase significantly with increasing catch weight at the aft end of the codend where most of the selection is known to occur. The results document the variation in potential size selection along a codend during a catch-build-up. It is emphasized that experimental studies aiming at describing the selectivity in different types of codends in a commercial situation, need to be based on catch levels representative for the commercial levels to prevent underestimation of the selectivity in the system, especially for designs to be included in the legislation.

It was additionally noted that escapement happens mostly in the area of catch accumulation. In response to questions, it was also noted that FISHSELECT methodology has been used. Mesh penetrations were simulated for each individual. Considering the relationship between catch weight and codend selectivity, studies with lower catches can underestimate size selection in commercial conditions.

8.1.2 Observation of Fish Behaviour During Demersal Trawling Operations in The Northeastern Mediterranean (Hüseyin Özbilgin)

Yeliz D. Özbilgin[1], Ebrucan Kalecik[1], Adem S. Bozaoğlu[1], Ahmet R. Eryaşar[1], Gökhan Gökçe[2], Hüseyin Özbilgin[1]

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This work presents main findings of fish behaviour observations carried out in two demersal trawls in Mersin Bay, Northeastern Mediterranean, between January 2011 and March 2013. Work was carried out in a total of 190 hauls between 2.5 and 400.7 m of water depths without using any artificial illumination. Five different models of cameras, with different levels of light sensitivities, were mounted in different sections of the trawls. Approximately, 450 hours of underwater recordings were made; 120 hours at the mouth area, 110 hours at the codend and 220 hours between these two sections including grid installations. A total of 30 different species have been identified in the recordings. Preliminary qualitative analysis of recordings showed that:

1) Very occasionally fish were observed to swim in the mouth of the gear. The usual observed behaviour is an immediate rise and drop back with the

approach of the ground line. This is so even for large fish (> 50 cm) and even at high water temperatures (>25°C);

2) Fish could only very occasionally be observed at the tunnel section due to the mud and sand clouds;

3) Many fish maintain swimming in the codend during the tow. However, with a reduction in towing speed, escape attempts increase. This is actually the moment where many escapees are seen from the codend meshes; in some occasions large fish are seen to escape by swimming out from trawl mouth;

4) Many species tend to hold station just in front of and behind a Super Shooter grid mounted in the extension, and the grid is usually but not always successful in releasing rays and sea turtles. Marine debris, mainly plastic bags, are very often seen to block grid systems.

5) Less than 1% of recordings are interesting. Trawlers should not reduce towing speed when hauling.

The aim of such experiments was to improve the understanding of how the fish are captured in the Eastern Mediterranean (Mersin Area). The area has several sea turtle nesting beaches, which might raise a call for fishing closures, so BRDs like TEDs (Super shooter type) were used. Cameras used are Bowtech Explorer, LCC 60, RD32, with battery and recording unit attached to a special frame and the GoPro Hero 2 and 3. Dolphins were shown to eat fish escaping from a trawl-eye.

8.1.3 Can we save toothfish, killer whales and fishermen together?

Gérard Bavouzet[1], Fabien Morandeau[1], Sonia Méhault[1], Jean Roullot[2]

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In 2003 a trawl ban caused shifting to longline in the area around Crozet Island (South Indian Ocean) to target toothfish. In 2008 issues were: bird mortality and killer and sperm whale depredation of longline catches. This presentation is about the ORCASAV-project for patagonian toothfish fisheries, with 7 longliners in the area. ORCASAV project aims to mitigate toothfish depredation by killer whales on longline around Crozet Islands (levels as high as 41% from 2002-2008). Eleven prototypes of fishpots, designed by a netmaker and tested in flume tank were successfully tested during an experimental survey in 2010. Underwater observations were done with cameras and many feedbacks came from videos recorded for further developments. A low impact grid was put in the bottom of the pot. In total 50-70 pots were used on each line, in depths of 500-2000 meters. Crab bycatch was a big problem, and gears were damaged by bottom contact. A longline was also tried, using 25000 hooks. During tests no fuel savings has been highlighted moving from longline to fish pot. Comparing results from different pots tested, the best pot shape was paralellipipedic, with 2 chambers, and 2 entrances. Some pots were baited with mackerel and squid, sardines, Japanese balaou, some other were foldable. Crab bycatch was one of the major issues due to the fact that they can block the entrance.

In response to questions, it was noted that more crew was needed to handle pots. Pots were baited with mackerel, squid, sardines and Japanese balou. The possible effect of camera lights on the behaviour was noted. Toothfish did not seem to be bothered by the light.

8.1.4 Swimming Performance of Fish in Capture Process Simulation Examined by EMG / ECG Monitoring and Muscle Twitch Experiment.

Mochammed Riyanto

Swimming performance of jack mackerel (*Trachurus japonicas*; 15.5-20.6 cm TL) was examined in a flume tank by measuring the stride length at low and high tail beat frequency with EMG and ECG monitoring. Stride length was analysed by monitoring of tail beat frequency according to the swimming speed at different temperatures of 10, 15 and 22°C. White muscle power output was calculated according to Tsukamoto, (1984). In sustained speed no white muscle activation has been noted, until prolonged and burst speed. The white muscle activity was detected at speed over 4.5 FL/s, by Electromyogram. The stride length was increased due to the large tail beating amplitude in higher speed. The maximum swimming speed was estimated with the muscle twitch experiment for calculating tail beat frequency, multiplied with stride length for higher tail beat frequency. Temperature effect was significantly ($P < 0.01$) for the muscle contraction time at different temperatures of 10, 15 and 22°C. The maximum swimming speed at 10°C was 11.3 FL/s (1.6 m/s) and was increased with the temperature as 15.9 and 16.6 FL/s or 2.3-2.4 m/s at higher temperature of 15-22°C range. The exhausted level after the forced swimming was also discussed with the length of recovery phase through Electrocardiogram monitoring.

It was clarified that the testing was done directly after exhaustion was observed. It was noted that this type of study is needed for behavioural models for many species. Energy consumption will differ for different swimming styles, and at maximum speeds, fish will change patterns.

8.1.5 Improvement of Size Selectivity and Short-term Commercial Loss in the Eastern Mediterranean Demersal Trawl Fishery

Hüseyin Özbilgin[1], Ahmet Raif Eryaşar[1], Gökhan Gökçe[2], Yeliz Doğanyılmaz Özbilgin[1], Sezai Bozaoğlu[1], Ebrucan Kalecik[1]

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Poor selectivity of demersal trawls targeting fish, crustaceans and cephalopods in Mersin Bay (Turkey) is a significant concern as common to most of the Mediterranean demersal trawlers. The majority of the boats working Mersin Bay trawl fishery use traditional gears with 44 mm mesh size hand knitted slack knotted multi-monofilament PE codends in which approximately 50% of the catch in terms of weight, and 70% in terms of numbers of individuals are discarded. The present study compares the selectivity of the commercial and three alternative codends (fabricated 40 mm square mesh, 44 mm, and 50 mm diamond mesh) for seven commercial species (red mullet (*Mullus barbatus*), brushtooth lizardfish (*Saurida undosquamis*), common pandora (*Pagellus erythrinus*), goldband goatfish (*Upeneus molucensis*), randall's threadfin bream (*Nemipterus randalli*), green tiger prawn (*Penaeus semisulcatus*) and speckled shrimp (*Metapenaeus monoceros*)). A total of 87 hauls were conducted by using the covered codend method aboard a commercial trawler on commercial fishing grounds in 2011. Selectivity parameter estimates were obtained with the use of "ccfit" function in "Trawlfunctions" programs for R. Likelihood ratio tests were carried out to evaluate if the pooled data selection curves estimated for all codends were statistically different from each other. Additionally, to evaluate switching from commercial codend to each alternative codends, short-term economic loss of the vessels in landing values for 31 marketed species were estimated. A total of 91 species were observed to enter the codends, among them 31 species were marketed in which red mullet and green tiger prawn provided more than 50% of the landing values. Results shown that the selectivity of the commercial codend is rather poor for almost all the marketed species. The 40 mm square mesh codend is the best alternative for majority of the marketed species in terms of releasing the juveniles with a commercial loss of 17% in landing values. Fisher's opinion indicates that unless fishery is subsidized, a switch from commercial to 40 mm square or 50 mm diamond mesh codends would be financially impossible and may cause to other illegal practices.

It was noted that in Scientific, Technical and Economic Committee for Fisheries (STECF) of the European Commission, there is an issue between North Sea and Mediterranean Sea. In 2006 a new regulation, 50 mm diamond codends or 40 mm square codends were suggested for the Mediterranean. Fishermen did not like square mesh, and may take steps such as mixing codends of square and diamond mesh to defeat regulations and the selectivity of the required codends.

8.1.6 Test of the Rope Separator Haddock Trawl on Georges Bank

Chris Rillahan and Pingguo He
School for Marine Science and Technology, University of Massachusetts Dartmouth, New Bedford MA , USA

Recent assessments of Georges Bank haddock (*Melanogrammus aeglefinus*) have shown healthy populations with no overfishing occurring. Conversely concern has been raised about Atlantic Cod, Yellowtail and Winter Flounder stock health. The goal of this project was to test a rope separator haddock trawl to eliminating bycatch on the offshore fishing grounds of Georges Bank, Northeast USA. A prototype net was used for sea trials conducted on board a commercial vessel in the spring of 2011 and 2012. The data showed very encouraging results – with substantial reduction in all fish species except legal-sized haddock. Mean catch of cod was reduced from 142.5 kg/hr to 16.0 kg/hr (88.75% reduction). Flounder showed equally promising results with yellowtail flounder and winter flounder reductions of 93.8% and 94.6%, respectively. Reduction in skates was 85.4%. Reduction in haddock catch was 9.5% reduction in 2011, and was not statistically different ($p = 0.1459$). In 2012 haddock catch was reduced by 55.7%, however the catch of legal sized haddock (<45 cm) was not significantly different between the two treatments ($p = 0.5167$). The catch of sublegal haddock was reduced from 60.8% (126.7 kg/hr) to 15.1% (14.4 kg/hr) of the total haddock catch.

A question was raised regarding the type of separator; rigid separators present challenges as trawls are flexible. However, this separator uses ropes with the flexibility to move with the trawl.

Another question on control of towing direction highlighted in trials the vessel turned then changed gear, which was stated to average out with enough replicates. It was also added that some subsampling of catch was done.

ToR a): Innovative dynamic catch control devices in fishing

Current activities within the institutes of several members of WGFTFB suggest that dynamic catch control is an important issue for several fisheries worldwide. Excessive catches are an acknowledged problem that result in increased mortality, reduced fish quality, and minimized fishing opportunities. Solutions pertaining to catch control are required by the authorities and fishers of different countries.

Several countries have conducted or are planning significant studies in this field but major improvements to the solutions presented are still needed. The creation of such a group would improve the cooperation between countries and institutes and would act as a SharePoint for the progress in the field.

Excessive catches are a problem, first of all because they often exceed the processing capacity of the vessel and consequently affect the quality of the fish delivered. In fisheries supplying fish for aquaculture where the fish needs to be taken onboard alive, excessive catches present an additional problem because of the lower survival chances of the fish when excessive amounts of fish are caught. In addition, excessive catch amount can lead to serious health, safety and environmental (H.S.E) concerns. In individual or group quota fisheries, excessively large catch can lead to diminished fishing opportunity for other species.

Excessive catches have so far been related to trawls, Danish seines and purse-seines, which demonstrates that this is a global problem in fisheries. Solutions for such a global issue will contribute to more responsible fisheries worldwide and reduced unaccounted fishing mortality through the reduction of discards.

8.2 General overview

This ToR was introduced by Eduardo Grimaldo at plenary and the participants met for a 3-hour session in which several individual presentations were held. The definition of dynamic catch control was initially discussed followed by a review of the fisheries and conditions where dynamic catch control can be an advantage. Some of the drivers for using catch control devices where identified and discussed. Finally, the group defined the scope of the ToR to specifically include trawl, seines and purse-seines.

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8.4 Terms of reference

The group will have the following terms of reference:

- Review the fisheries, conditions, and impact on mortality where dynamic catch control can be an advantage and consider/share recent improvements towards commercial fisheries.
- Provide improvements/solutions for the challenges related to excessive catches that are encountered in the different fisheries and gears worldwide.
- Produce a report including a review of the status of knowledge and technology on the subject, with identification of technology gaps, and recommendations for future research on the technology for the different fisheries and fishing gears.

8.5 Individual presentations

8.5.1 Catch control devices for trawls (Eduardo Grimaldo, SINTEF Fisheries and Aquaculture)

The cod fishery in the Barents Sea has shown in recent years an increasing tendency for single catches that exceeded 50 tons of fish in just a few minutes' towing. High density of fish means that large quantities of fish enter the trawl in just few minutes, and this is difficult to control even with electronic monitoring sensors attached to the trawl. Big catches can be associated with poor quality of the catch, but also with health and safety related problems (Figure 1).

In addition, problems associated the lack of sorting capacity of mandatory sorting has accentuated the problem. The sorting grid appears to reduce the water flow inside the trawl, and as a consequence fish accumulate in front and behind the grid, not falling back to the codend. In this circumstance the catch sensors do not give the real picture of the total catch in the trawl (Figure 2).

Some of the techniques for controlling the catch size that have been recently tested are:

- Detaching techniques: The working principle of this technique considers a codend that partially detaches from the extension piece after a certain (desired) catch has been reached (Figure 3). Three ways of codend detachment have been tested: 1) Codend will be detached from the extension piece using an acoustic releaser, two rows of rings and a fitting of rope (Figure 4A) 2); Acoustic releaser in combination with a weak link (1.8 mm twine) and supporting rope (Figure 4B); 3) Weak link and catch sensor technique (Figure 4C).
- Side openings in the codend: The working principle of this technique is based on side openings that progressively open as the codend builds up. A fish lock panel is also used to avoid loss of fish from the codend. Once the codend is full all excess fish in the extension piece are gently released at depth (Figure 5).

Flume tank observations and videos were shown.

Discussion:

The acoustic released technique work well but demands a lot of attention and additional time to attach the codend to the extension piece. Also, it demands additional people to use the control unit and to operate the portable transducer. Finally, it is an expensive solution. The weak link technique is much simpler and cheaper than the acoustic releaser technique. Still fishermen are reluctant to use additional time attaching the codend to the extension piece. The side opening technique worked very well, and is a simple and cheap solution. However Norwegian regulations forbid the use of funnels and or locks inside the fish codends.

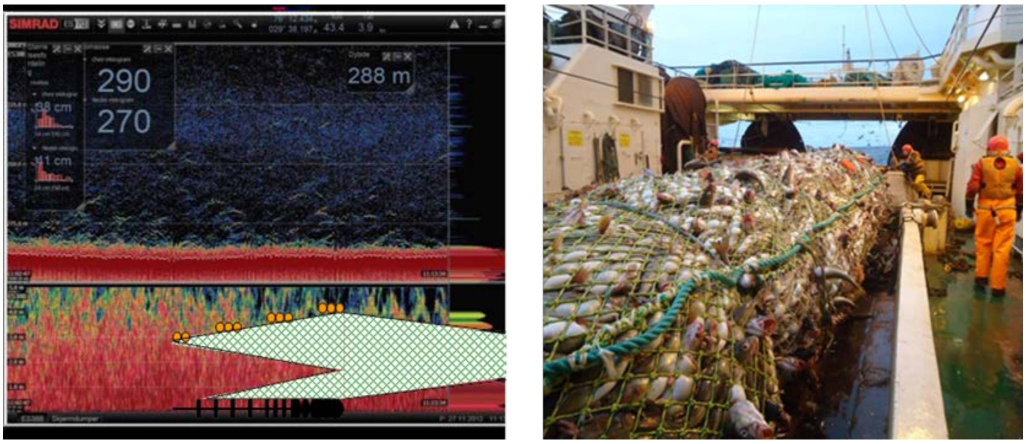

Figure 1. Photographs showing the availability of cod and the relative size of a commercial bottom-trawl (left) and the codend with the resulting catch after 10 min tow (Source: SINTEF).

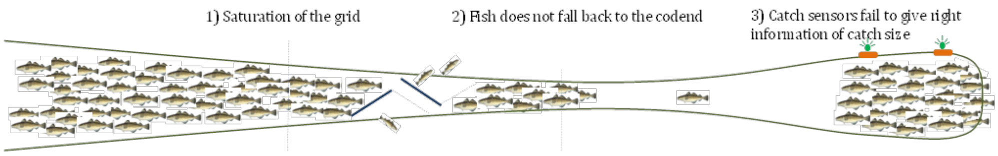

Figure 2. Consequence of large densities of fish meeting simultaneously the sorting grid.

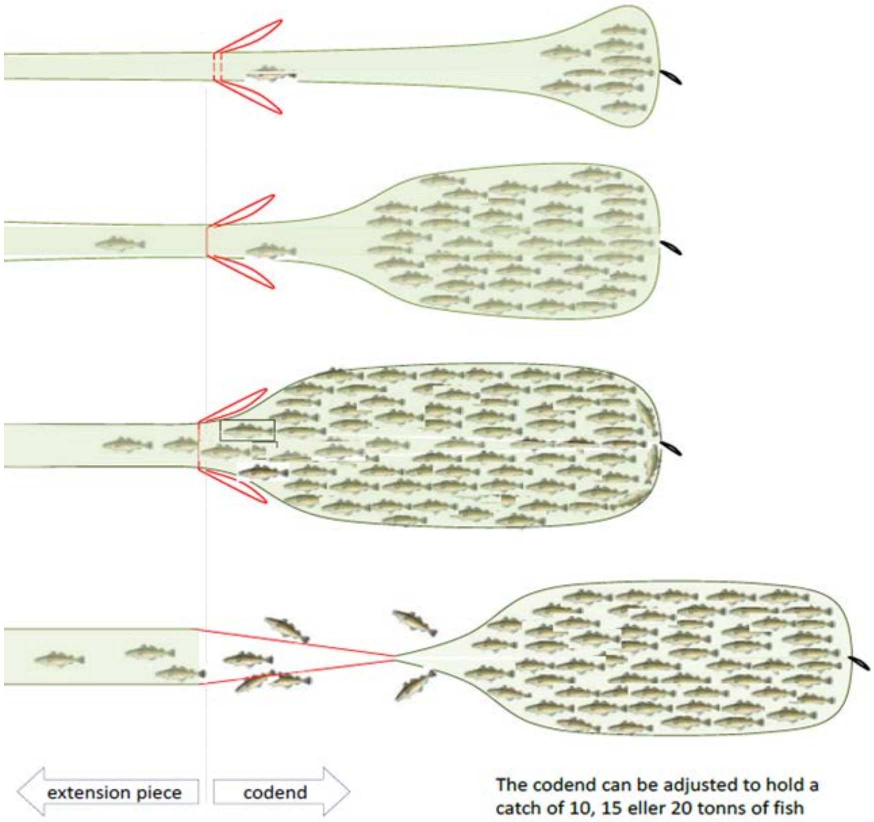

Figure 3. Working principle of the detaching codend.

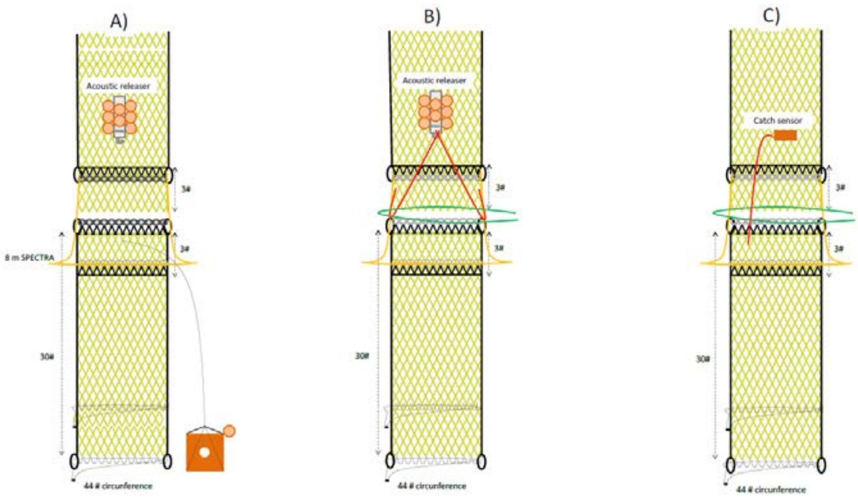

Figure 4. Detaching techniques.

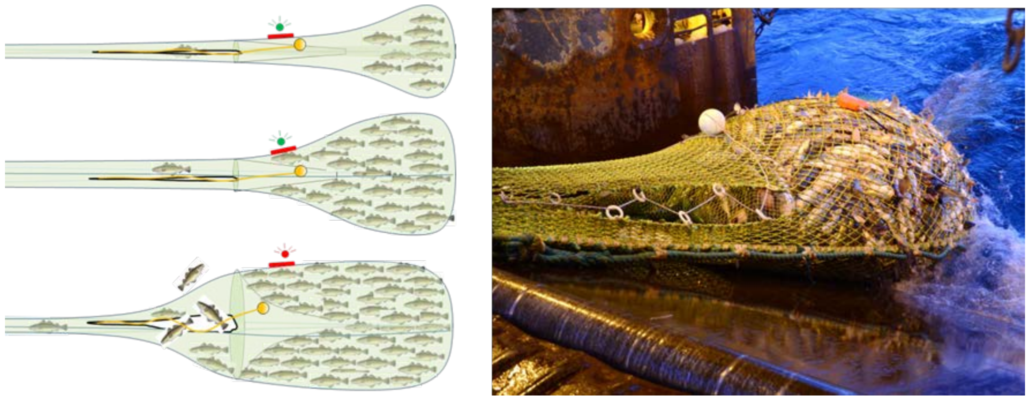

Figure 5. Side openings in the codend and fishing lock.

8.5.2 Catch regulations in trawl fisheries (John Willy Valdemarsen, Institute of Marine Research, Norway)

Large stocks of cod (*Gadus morhua*) and haddock (*Melanogramus aeglefinnus*) in the Barents Sea can result in big catches with trawls and seines. Big catches are difficult to avoid when catch rates are in the order of 50 tons in 5 minutes tow. Catch sensors in the trawls are not efficient behind mandatory sorting grids. As a consequence big catches result in net bursting, discard and/or poor product quality caused by the long production time. Therefore there is a need for systems that can limit the amount of fish in the trawl. Several systems are under development, but simple and inexpensive devices have shown potential for solving this problem. Some of the techniques that have been considered and/tested so far are:

- Thin twine that breaks by drag of catch or expansion of the codend.
- Split in the N-direction in forward part of codend.
- Meshes that open as codend fills up. Parallel bungee (elastic) ropes with cross-bars easily opens when speed reduces so fish come forward and escape (Figure 6).
- A motorized gate that opens up on a signal from an operator (Figure 7)
- A hatch in the upper panel that opens up when the codend fills up. This device is based on a hole in the codend's upper panel that is covered with a rubber mat (flap). The flap stays closed until the flow dynamics and swelling codend opens flap. There is a fish lock fixed inside the codend to avoid loss of fish (Figure 8 and Figure 9).

Discussion

The rubber mat technique is simple and is a low cost solution. Norwegian authorities are allowing five trawlers to test this technique in the commercial fishery this year. Fish lock prevents fish from coming forward. The active catch release system (motorized gate) requires lots more instrumentation. Testing of catch control techniques in seine fisheries has just started.

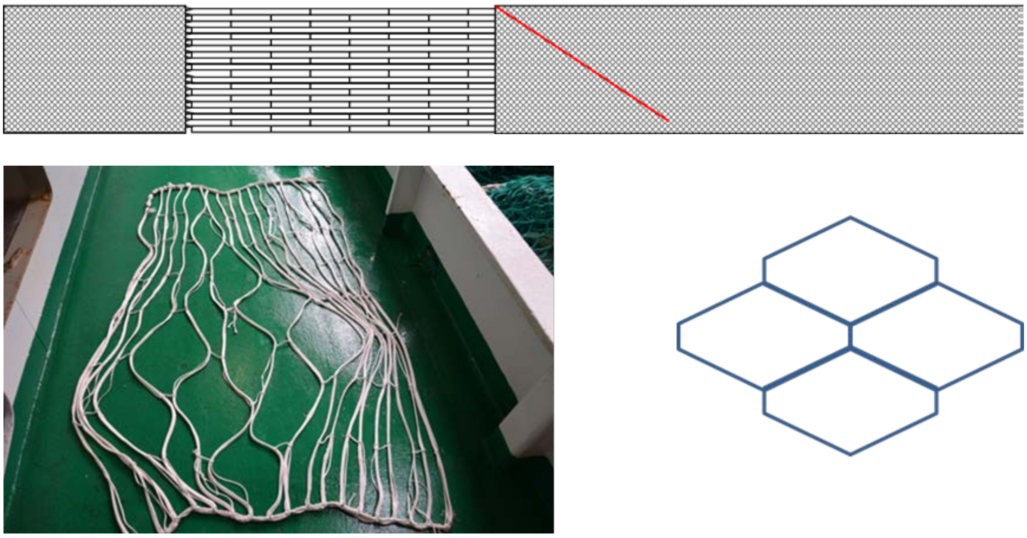

Figure 6. Fish release through "meshes" that open up when codend fills up.

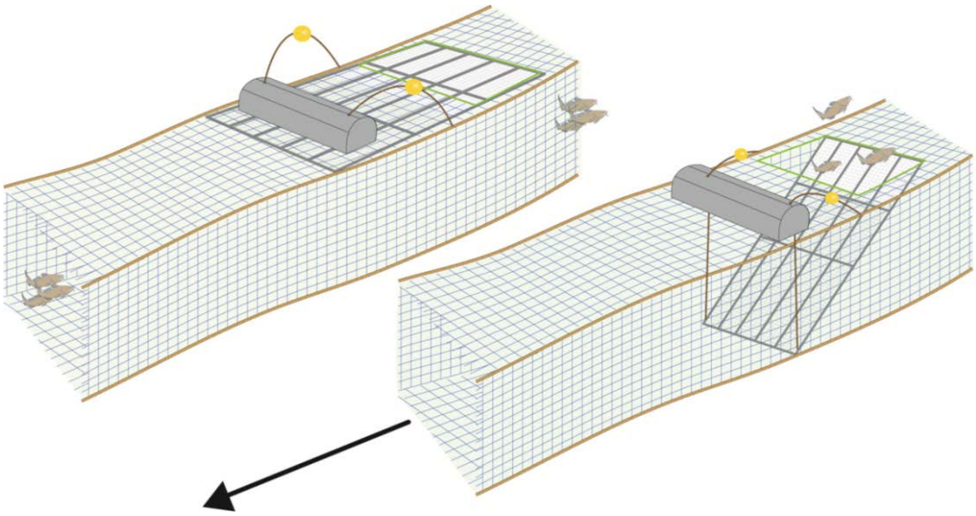

Figure 7. Active catch release system: Motorized gate that opens up on a signal from an operator.

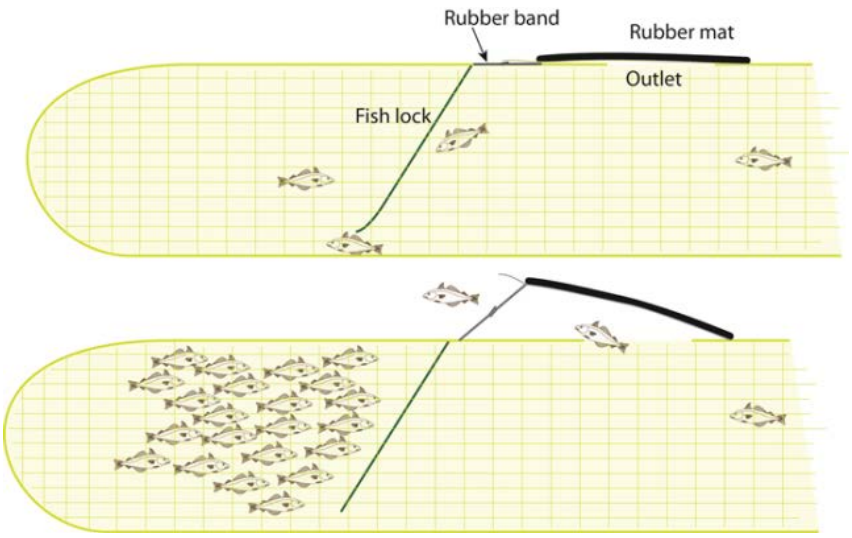

Figure 8. Working principle of the hatch in the upper panel that opens up when the codend fills up (rubber mat and fish lock; source: CRISP).

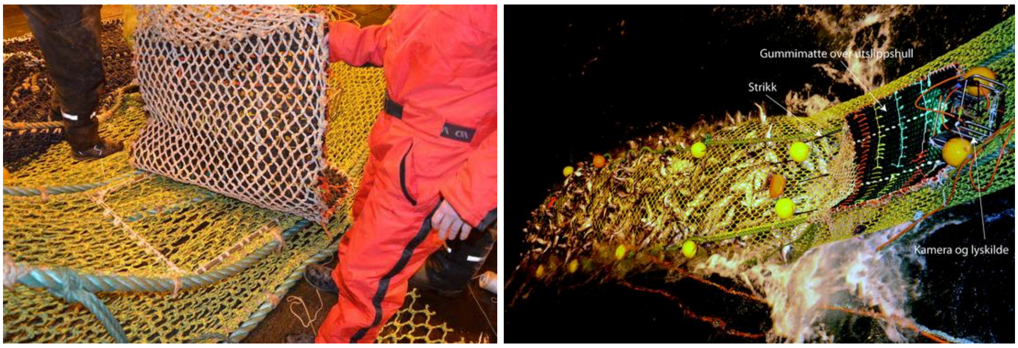

Figure 9. Catch control device based on a rubber mat and a fish lock (Source: CRISP)

8.5.3 Self-Closing Codend (Mike Pol, MA Division of Marine Fisheries)

A network of fishermen, gear manufacturers, and research have designed and developed an innovative and inexpensive underwater codend that closes off after catching a preset, adjustable, volume of fish in order to limit catches of "choke" species. Additional fish that enter the net escape easily. A parachute also releases, creating drag and signalling to the boat that the codend has tripped (Figure 10).

The self-closing codend was designed to limit the amount of fish that can be caught in a trawlnet. Output controls and strict catch limits (especially for “choke species”) have made catching too many fish a risk to prematurely ending a vessel’s and/or sector’s fishing season. Acoustic catch sensors, which alert the vessel when the codend fills, are a costly solution that does not solve the problem of large catches that fill the codend quickly. Conceived by Capt. Murphy, our innovative codend provides a cheap alternative that quickly clinches tight after catching a preset, adjustable volume of fish; additional fish that enter the net escape safely and easily through the open portion ahead of the closed codend. A parachute also simultaneously releases creating drag and signalling to the vessel that the codend has tripped. Underwater video of the design was collected on-board a small groundfish trawler, the “Bantry Bay”, in Massachusetts Bay, June-July 2011. Results indicate that the codend successfully and repeatedly triggered and fish were unable to enter the codend once it cinched off. The parachute also deployed as expected but was undersized to provide adequate drag to alert the vessel. We plan to verify the codend's operation and further refine the design with flume tank testing and expanded field testing to other vessels, with additional collaboration as more fishing experience is brought into the idea.

Dumping the catch is not a good solution, can be dangerous, and is time consuming. The upper and lower (fore and aft) codend were laced together with a zipper line using rings and a simple door bolt. A trigger line reacts on expansion of the bag due to filling. The parachute opens triggered by the line and tightens the codend. This is a cheap solution costing $750 for new equipment. Videos were shown.

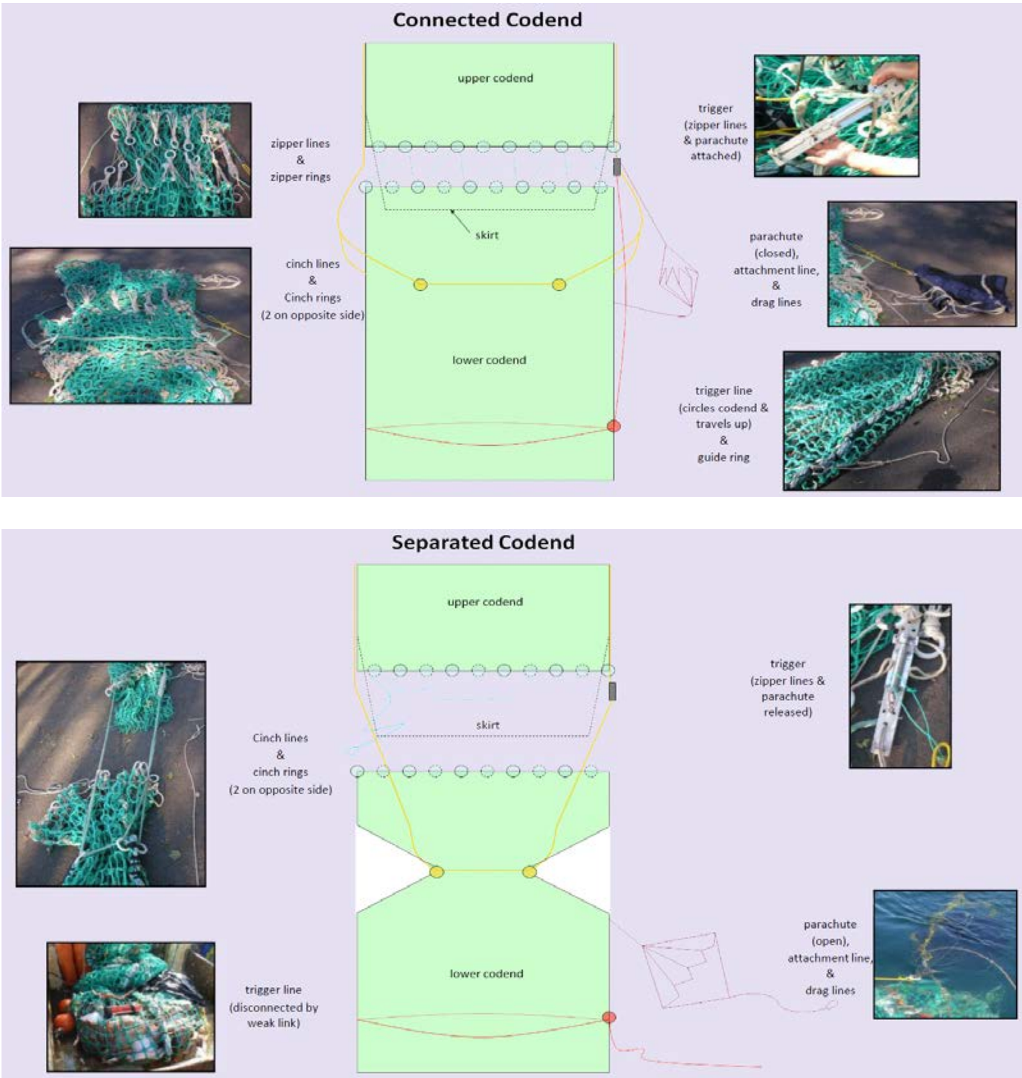

Figure 10. Illustration of the working principle of the self-closing codend (Source: David Chosid and Mike Pol).

8.5.4 Mackerel zipper line (Haraldur Einarsson, Institute of Marine Research, Iceland)

Zipper lines in the upper panel of the extension piece are occasionally used in mackerel trawls in Iceland to prevent having unwanted big catches. These zipper lines break and unzip when the codend fills up. Catch rate differences were noted between boat types and skippers were convened. The catch rate data were showed to the skippers and proposed to ban the method of controlling the catch size. However, the skippers justified the use of methods by the worry of losing their trawls.

The Icelandic cod fishery also has problems with big catches. Iceland has considered banning grids since they can't control catch and catch sensors don't work. Also poor quality results from fish stuck in the grid, which may then be discarded when processed; up to 9% of fish are damaged.

8.5.5 Main Outcomes

A preliminary definition of dynamic catch controls was made: "Dynamic catch controls are systems that change the structure and functioning of the gear during the fishing operation so that the gear stops collecting fish when the desired amount of fish has been retained by the gear and actively release excess fish".

The group identified the drivers for using dynamic catch controls. Some of the most relevant are: control of catch size; release of excessive catch without harm; keep fish alive for freshness; quality and pricing; safety.

The group reviewed the fisheries, conditions, and impact on mortality where dynamic catch control can be an advantage.

The group provided an overview of a series of techniques that has been used in different fisheries around the world. Special attention was put on dynamic catch controls that are currently been tested (or recently has been tested) in the Barents Sea demersal fishery, and in the mixed groundfishery in the USA.

We defined the scope to specifically include only trawls, seines and purse-seines. In other than these gears the group did not identify a need for dynamic catch control. The group agreed on not including separator trawl techniques (separator panels, separator ropes, eliminator trawl, etc.) as dynamic catch controls systems.

The group will try to recruit expertise on purse-seine work in regard to releasing of undersized fish.

Recommendations

The ICES/FAO WGFTFB Topic Group on Dynamic Catch Controls makes the following recommendations to the ICES/FAO WGFTFB:

- Collaborations have been established between members and will continue outside the context of meetings of WGFTFB.

9 ToR b): Future applications of artificial light in fishing gear design and operations

9.1 Background

It is thought that artificial light, in the form of fire, has been used in fishing for thousands of years (Ben-Yami, 1978). In the presence of artificial light, pelagic fish often school and move towards the light source and this technique is successfully employed in several fishing methods (Ben-Yami 1978; Gabriel *et al.,* 2005). Commercial applications of light in purse-seines, lift nets, and squid jigging are widely practiced, especially in Asian-Pacific countries. In jigging, hook and line, dipnet and purse seine fisheries, artificial light sources are used to attract and aggregate squid and pelagic fish such as sprat, herring and mackerel (Ben-Yami, 1988). In long-lining, light-sticks are widely used to encourage swordfish to ingest the baited hook (Hazin *et al.,* 2005). Indeed there are few fishing practices in which light is not sometimes used to attract or concentrate fish, and few fishing gears that are not sometimes used in combination with light to attract the fish (Gabriel *et al.,* 2005).

Today, fire and gas lamps have been replaced by incandescent lamps, metal halide lamps or fluorescent lamps as the source of light these fisheries. While more convenient, safer and significantly more powerful, with respect to the light emitted, these lamps have generated new problems for the light fisheries in which they are used. Firstly, competition between boats and métiers has led to an excessive level of light output from many established fisheries (Matsushita *et al.,* 2012). As a result, the vessels incur increasing fuel costs and have an increasing environmental impact, in terms of light pollution and CO2 emissions. Furthermore, this excessive level of competition, if unchecked, could easily generate a technological creep in catch per unit of effort and thus lead to overfishing.

Commercial applications of artificial light for fishing have tended to be confined to surface or subsurface lights in fisheries that target pelagic and schooling species. Technological limitation partly explains the lack of application in demersal and deepwater fisheries. Light systems operated at greater depths have mainly used battery packages for energy supply because cables were impractical. These batteries were heavy and with a comparatively short life time and therefore not very suitable. However, recent technological advances in battery and modern LED light technologies (Inada and Arimoto, 2007) have made available small, robust, powerful and energy-efficient light units that can be used in deeper waters for both static (e.g. pots and longlines) and towed fishing gears (e.g. trawls). Moreover, these new energy efficient light sources are continuing to develop and may be used to develop energy efficient and environmentally friendly fishing technologies for existing light fisheries.

Many explanations have been offered to explain why fish respond to light, including conditioned responses to light gradients, curiosity, social behaviour, phototaxis, optimum light intensity for feeding, and disorientation and immobilization due to high light levels (Arimoto *et al.,* 2011). However, despite many years of research into fish visual systems, knowledge of the role of vision in the capture process is still limited. The functional explanations for responses to light, whether repulsion or attraction, include predator avoidance and enhancement of feeding efficiency (Pitcher and Parrish, 1993). The type of responses and their functional explanations depend on species, ontogenetic development, ecological factors, and physical characteristics of the light source (intensity and wavelength; Marchesan *et al.,* 2005). As technological improvements enable research into the responses of species previously unexposed to artificial light (i.e. in demersal and deep-water fisheries), there is great potential for developing innovative solutions to longstanding bycatch and selectivity challenges using artificial light.

A synthesis of the knowledge of light fishing and the fundamental responses of fish to artificial light will provide a comprehensive overview of the topic and stimulate research into the innovative application of artificial light; in both established light fisheries and in demersal and deep-water fisheries, where the technology remains relatively untested. There is considerable potential for artificial light to be used constructively in the development of more efficient and responsible fishing methods. This ICES/FAO Topic Group on the Use of Artificial Light in Fisheries offers an important opportunity to combine and coordinate the research activities of scientists from the ICES community, with an interest in developing light as innovative technique, with scientists from the FAO community (particularly Asia), who have a great deal of experience working with traditional light fisheries.

9.2 Overview

The second meeting of Topic Group on the Use of Artificial Light in Fishing was held on 9th May 2012, as part of the ICES-FAO 2013 Working Group On Fishing Technology and Fish Behaviour Meeting, and convened by Mike Breen. In conjunction with this meeting, there was also a session on the Use of Artificial Light as a Stimulus in Fish Capture in the ICES-FAO Mini Symposium "Impacts of Fishing on the Environment" which is summarized above and fully reported separately by FAO.

Due to the limited time available, this TG meeting aimed to build on previous discussions and correspondence, and focus on developing two specific ToR:

- Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture; and
- Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing sustainable fishing methods.

In the first TG meeting (Lorient, France, 24–27 April 2012), it was recognized that to research the process of light fishing was a multidisciplinary task, involving the fields of: fishing gear technology, marine optics, engineering, vision biology and animal behaviour. Practitioners from these fields were invited to participate in the 2013 TG meeting and were initially divided into five specialist subgroups:

- Fishing Technology and Practice (Lead by Prof Zhou)
- Ocean Optics (Lead by Amit Lerner)
- Engineering (Lead by Dan Watson and Heui Chun An)
- Biology of Vision (Lead by Prof Ronald Kröger)
- Behaviour (Lead by Anne Christine Utne Palm)

Each subgroup was asked to discuss and summarize the necessary experimental designs (in their discipline) that would be required to investigate the behaviour of fish in response to artificial light sources. These discussions included what required input data/information they would require from the other discipline groups, what information they could provide to those groups (and their limitations); as well as the protocols and technology required to conduct the work. In addition, the Fishing group was asked to identify key challenges and research priorities in current light fisheries.

9.3 Terms of Reference

The Topic Group worked to the following terms of reference:

"A WGFTFB topic group of experts will be formed in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions.

Specifically the group aims to:

- *Describe and summarize fish response to artificial light stimuli;*
- *Describe and summarize use of artificial light in world fisheries;*
- *Describe and tabulate different light sources to attract fish;*
- *Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions;*
- *Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing sustainable fishing methods; and*
- *Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture.*

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9.5 Overview of the Topic Group’s Work to Date

A brief summary of the work accomplished by the TG was presented by Mike Breen:

ToR 1: Describe and summarize fish response to artificial light stimuli

- Marine Optics – essential elements for fisheries biology (YM *et al*; Completed)
- Visual spectrum (retinal pigments) of different species (ACUP *et al*; In progress)
- Behavioural responses to light (SL *et al*; In progress)

In support of these reviews, and other associated research, the group has established a database of relevant literature.

ToR 2: Describe and summarize use of artificial light in world fisheries

- Identify regional correspondents to produce regional reports/overviews of light fishing (MB); (In progress)
- Produce a summary description of light fishing techniques – industrial and artisanal (HCA and Prof Z); (now underway)

- Investigate the feasibility of using remote sensing to support a global review of light fishing (MB, BEA, PH, YM). (Limited progress)

ToR 3: Describe and tabulate different light sources to attract fish

- A technical review of the sources of light applicable for use in fisheries (HCA; In progress)

ToR 4: Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions

- Need a more comprehensive global overview of the light fishing sector.

ToR 5: Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods."

- A review on "The Innovative Use of Light in Fishing (PH *et al.*)" (In progress)

ToR 6 (Additional): Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture

- Task – Review light measurement protocols and instrumentation requirements (MB and AL; In progress)
- Task – investigate the feasibility of establishing common facilities for the measurement of light irradiance and transmission (MB; In progress)

This year's meeting focused on the following ToR:

- Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing sustainable fishing methods."
- Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture

9.6 Main Outcomes

In the previous TG Light meeting (Lorient, France, 24–27 April 2012), it was recognized that to research the process of light fishing was a multidisciplinary task, involving the fields of: fishing gear technology, marine optics, engineering, vision biology and animal behaviour. Practitioners from these fields were invited to participate in the 2013 TG meeting and were initially divided into five specialist subgroups:

- Fishing Technology and Practice (Lead by Prof Zhou)
- Ocean Optics (Lead by Amit Lerner)
- Engineering (Lead by Dan Watson and Heui Chun An)
- Biology of Vision (Lead by Prof Ronald Kröger)
- Behaviour (Lead by Anne Christine Utne Palm)

Each subgroup was asked to discuss and summarize the necessary experimental designs (in their discipline) that would be required to investigate the behaviour of fish in response to artificial light sources. These discussions included what input data/information they would require from the other discipline groups, what information they could provide to those groups (and their limitations); as well as the protocols and technology required to conduct the work. In addition, the Fishing group was asked to identify key challenges and research priorities in current light fisheries. The initial focus was on intra-group discussion, to establish an overview of the disciplines' capabilities and methodologies for researching light fishing, but also to identify knowledge gaps and information needs. Following this, inter-group exchanges were encouraged to develop an understanding of common challenges and to address the questions "What do you need?" and "What can we provide?".

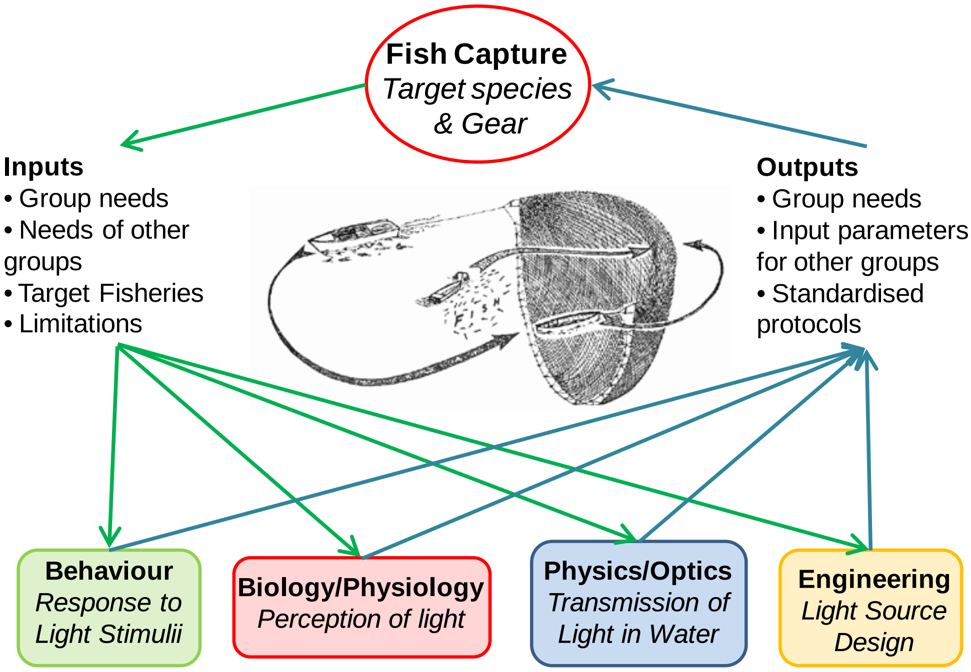

Figure 2.1. Overview of the discussion group structure.

The following sections are summaries of the discussions and recommendations from these subgroups.

9.6.1 Fisheries Technology and Practice

The existing fishing gear and methods using artificial light, of which there are mainly two types (i.e. guiding and aggregating), can be summarized as follows:

<u>Guiding Techniques -</u> Using lights set on the leading net of set-net (traps) to attract or guide target species to the entrance of the set-net. Alternatively, light may also be combined with electrical fishing techniques, where fish may be attracted using moving light patterns towards fish pumps, around which an electrical field has been induced. Fish will tend to swim towards the positive electrode (anode) in the mouth of the pump and sucked into the fishing vessel (e.g. sardine and herring).

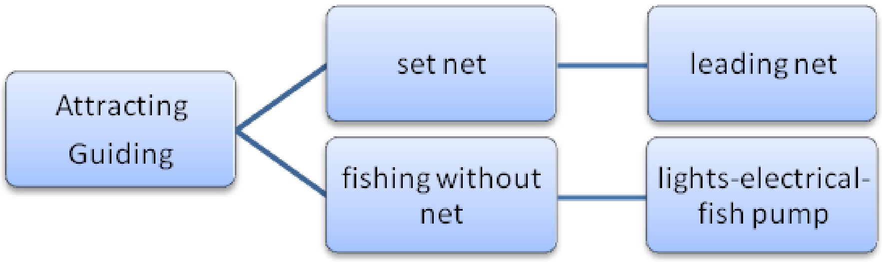

Figure 2.2a. Examples of Guiding Light Fishing Techniques.

Aggregating Techniques - Using lights to attract target species into dense aggregations, after which they are collected using an appropriate fishing gear (e.g. purse-seine, lampara, dipnet, jigging, etc.).

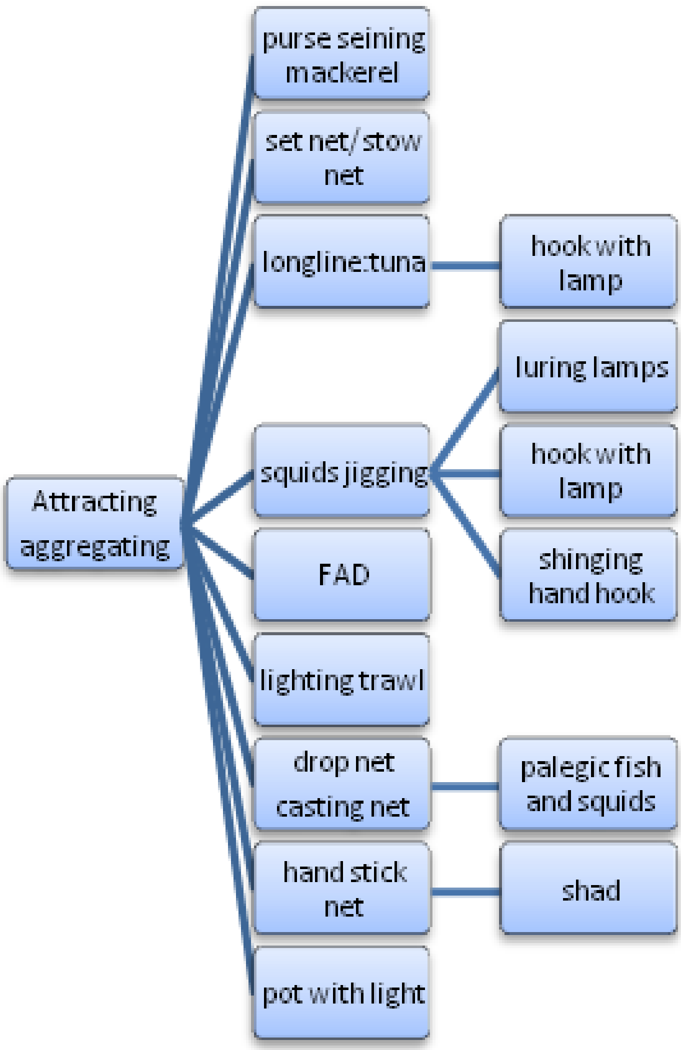

Figure 2.2b. Examples of Aggregating Light Fishing Techniques.

Any research into the development of light fishing, in addition to a full description of the artificial light source, its energy efficiency and the light field it produces, will need to understand the visual capabilities of the target species and describe their behavioural responses to the artificial light sources throughout the fishing operation. This will require considerable investment in expensive and instrument (e.g. underwater video and acoustic cameras (e.g. DIDSON), scanning and multifrequency sonar, etc.), for which it may be worthwhile developing a common repository of such equipment for the mutual benefit of all researchers working in this field.

For example: squid can be attracted by lights, but they stay in the shadow area beneath the vessel, occasionally venturing into the edges of the light zone. What is the mechanism driving this behaviour: are they seeking food, i.e. plankton, attracted by lights, but try to avoid illuminated zones because of risks of predation? Alternatively, this nocturnal and highly visual predator may be limited by the light intensity, either directly through a process of photoreceptor bleaching and temporal blindness or indirectly by insufficient target detection due to lowering of its contrast vision by the high intensity light field. That is, the squid may stay at the edges of the light zone where the light intensity is optimal for its visual capabilities.

What modifications can be made to improve the efficiency of this capture process?

Squids jigging, casting nets and drop net, hand stick net are used extensively in Asian light fisheries. These fisheries consume a lot of electricity, so a project to increase the energy efficiency of these techniques by: deploying the light sources underwater (to minimize losses at the air/water interface), harvesting renewable energy from the marine environment; and optimizing the emitted spectrum of light, through a more thorough understandings of the target species visual capabilities and behavioural responses will be valuable.

<u>Research Priorities:</u>

1) A review of existing light fishing techniques to collect detailed information on practices and lighting technology, as well as the behaviour of target species during fishing operation.

2) Improve the energy efficiency of existing light fishing techniques (e.g. squid-jigging with lights; purse seining for herring, etc.). For example, by replacing existing light sources with more energy efficient technologies (e.g. LED). Also, by optimizing the emitted spectrum (with respect to wavelength, intensity and flicker) and combinations/sequences of lights specifically to the target species, thus removing unnecessary wavelengths, it may be possible to make considerable energy savings.

3) Improve sustainability of established fisheries with innovative use of light. For example, improving species and size selectivity in mixed species fisheries (e.g. Nephrops trawl fishery in the North Sea), by utilizing inter- and intra- species differences in responses to artificial light to manipulate behaviour during capture and promote the escape of unwanted fish. Also, developing FADs with light fields (and other stimuli) that attract tuna but drive dolphins away.

4) Develop the efficiency of alternative, environmentally sustainable fishing methods by using light. For example, it has been established that cod (and other gadoids) aggregate around artificial lights, to feed on krill that have been attracted to the light. The development of fish pots as a sustainable al-

terative to trawling and gillnetting could be enhanced if the catch efficiency of pots could be improved using light as an attracting stimulus.

9.6.2 Ocean Optics

This subgroup summarized a process by which the use of artificial light as part of the capture process within a fishery could be investigated and developed (figure 2.3).

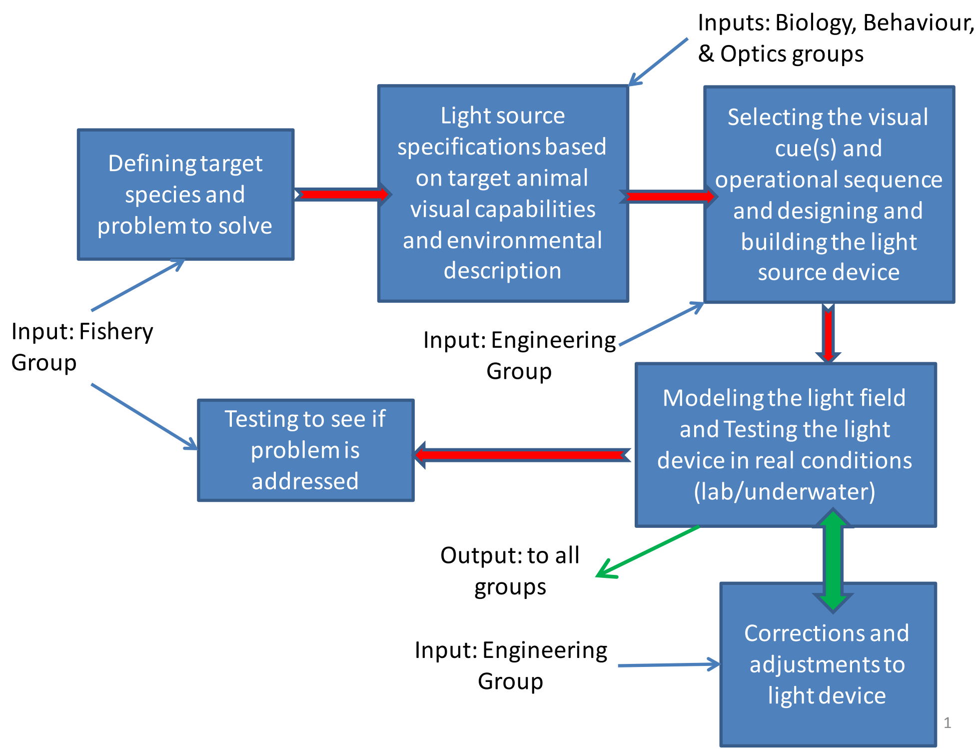

Figure 2.3. A process for investigating and developing the use of artificial light as part of the capture process within a fishery.

Using this overview, it is possible to define the necessary inputs from the various disciplines that the Ocean Optics discipline would require to investigate and develop the use of artificial light as part of the capture process within a fishery.

Inputs required by the Ocean Optics group:

- Definition of specific problems to address (from Fishery Group);
- A full biological description of the target species, and/or optional 'satellite' species (i.e. those that may affect the behaviour of the target species; e.g. predators and prey; with respect to visual capability and known behavioural responses to light; From Biology and Behaviour Groups);
- A technical description of the fishery in terms of the fishing procedure (from Fishery Group);
- Light Source Requirements – the required light intensity/spectrum/polarization based on the target species' visual capabilities

and responses, and, if necessary, sequence of changing visual stimuli. (from Biology and Behaviour Groups);

- Light Source Specifications – in terms of the available lighting technologies, power usage and spectral output of the artificial light (from Engineering Group);
- A description of the environmental conditions associated with the fishing operations, including the optical properties of the water (From Fishery and Biology Groups); and
- Feedback on the success and limitations of ongoing developments in each of the other disciplines.

Outputs from the Optics Group

- A definition of the best practice for measuring light (natural and artificial) and the optical properties of water in the laboratory and field (to all groups);
- Consultation (and training) and quality assurance in the collection of standardized light measurements and the optical properties of water in the laboratory and field (to all groups);
- Describing the optical properties of the water type in which the fishery takes places;
- Consultation in defining the specifications and design of the light source according to the target species, water type and fishing operation;
- Consultation on the testing and development of the artificial light source (in laboratory and field); and
- Provision of a model for describing the light fields produced by the artificial light sources (to all groups).

The Protocols and Technologies to be used by the Ocean Optics Group:

<u>Light Measurement Protocols and Workshop</u>

- Protocols for using devices such as radiometers and polarimeters to measure light field intensity and polarization underwater.
- Giving workshop at user location on how to use and measure light field.

<u>Measurement Devices:</u>

- Radiometers (radiance and irradiance) to measure light attenuation with distance or depth.
- Turbidity meters to evaluate and validate scatterers concentrations and define water types.
- Submersible Polarimeter: spectrophotometer (e.g. JAZ) attached to 3 optical fibers at 3 polarization orientations. The device goes underwater, and is operated manually or automatically (depending on depth).
- Video and stills imaging (both in lab and field) to evaluate light parameters (Intensity and polarization spectra), attenuation, contrast depletion, flickering etc.

Image analysis

- Developing and applying computer codes to analyse light field from movies or stills (Matlab, ImageJ etc.).

Modelling

Developing a user friendly computer code to calculate resulted light field (intensity and polarization vs. wavelength and scattering angle out of incoming radiation (light source), in a given water type. Inputs for the model: light source details (wavelength, intensity, polarization, direction), water content (scatterers: type (refractive index), shape (sphericity) and size distribution), viewer details (viewing direction, depth…), and viewer visual capabilities (sensitivity) and resolution spectra (wavelength), contrast and polarization thresholds, CFF (flickering rate) etc.

9.6.3 Engineering

The engineering group, after defining their own capabilities and requirements, circulated throughout the groups and asked each one how technology might be able to help them. Particular focus was put on what technical requirements they had concerning artificial light, the specifications of which are broadly outlined below. The first question was, "What do you need?" and the second question, "What can we offer as engineers?".

Question 1 - What do you need?

The responses to this question can be categorized into two sections:

1) The first concerns the nature of the light source and how it can be controlled. Responses suggested that it would be useful to be able to control:
   - Wavelength
   - Flicker rate
   - Polarization
   - Intensity/Brightness
   - Directionality
   - Projection angle (radiance vs. irradiance), i.e. how wide is the beam of the light source?

2) The second set of responses concern how a device (or set of devices) that houses the light source (single or many) might be controlled by its users. Responses suggested it would be useful to be able to control/specify:
   - Patterns
   - Shadowmaking (shapes/sizes/intensity)
   - Number of light sources
   - Any further mechanical elements (modularity/attachment mechanism)
   - Module -> module interaction
   - How smart/responsive the devices should be to fish behaviour/reaction

Question 2 – What can we offer as engineers?

The engineering group discussed the responses to Question 1 and began to understand what sort of engineering/design support could be necessary during the next phase of the investigation.

Equipment design support

- Electrical/electronic (Power, light types, etc.)
- Mechanical (Casing, material selection, etc.)
- Programming (Patterns, repetition, sense, etc.)

Prototyping

- Physical devices
- Strength/feasibility study

Manufacturing advice

User-centred design process

- How will the devices be used by:
    - Scientists
    - Fishermen

Information on state-of-the-art technology from within and outside the fishing industry.

- Including a review of all available light sources (surface and underwater) suitable for fishing operations.

Initial thoughts

The responses from the different groups pointed to the need for very variable light sources to be used in testing and this could be achieved in a number of ways:

- A system of modular devices, packed with different light sources and polarization devices, that can be programmed to create patterns, etc. (The Swiss Army Knife approach)
- Individual units that use a particular light source at a set wavelength, but can control various elements (flash speed, intensity, etc.).
- Wired devices that can be controlled from the deck of a research vessel.

Supplying sufficient power to these devices is an issue that has to be addressed. However, in terms of prototyping there are simple developments and programming tools that mean it may be possible to build working test-devices relatively quickly.

9.6.4 Biology and Physiology

Marine organisms live in a world alien to humans and are difficult to study. The constraints being met by marine animals are vastly different from our own experiences, such that any intuitive understanding of their biology, physiology, and sensory capacities is most often incorrect and misleading. Current knowledge of the biology and physiology of species important in fisheries worldwide is generally poor and controlled studies are necessary in order to achieve a more accurate understanding.

This group will address the visual capabilities of marine animals and the use of light in fisheries. The aim of the work is to provide the users, i.e. the fishing industry and policy-makers, with information on the visual biology of target species, and in some cases bycatch species. This information can be used to design more efficient and selective harvesting methods and to formulate policies for the sustainable use of natural resources. Biological information will be gathered and distributed to achieve and maintain a viable industry with minimum negative impacts on human populations and the environment.

Light in shallow waters

Clear water is penetrated by sunlight to a depth of several hundred meters. In the open ocean, vision based on sunlight may be used to a depth of up to 1000 m. However, even clear water scatters light, which creates a veiling effect that limits visual distance. In the clear-blue water of the open ocean, visual distance at daytime is less than 50 m. Only under extreme circumstances and against a dark background, a light signal may be detected from a distance of up to 150 m. Vision is thus a short-distance sense in water.

Coastal and estuarine waters may be turbid because of scattering particles such as clay or photosynthetic bacteria. Such waters may also be coloured by dissolved organic matter (*gelbstoffe*). Water turbidity and coloration limit the penetration of sunlight and visibility, as well as shift the available spectrum of light towards longer wavelengths (red). The variable underwater visual environment has led to the evolution of many different visual capabilities, allowing marine organisms to gather a maximum of sensory information under difficult circumstances.

Light in the deep

Deep waters are often considered as light-less zones. However, most animals living in these habitats have eyes and sophisticated visual systems. These capacities come at a high cost to the animals. As a rule of thumb, 5 to 20% of the energy expenditure of a fish is used for the eyes and visual system. If vision cannot be used, such as in freshwater cave environments, eyes are rapidly lost through evolution. This indicates that species with eyes use vision for important tasks.

One major visual task in deep waters is the detection of bioluminescent signals. These may be passive, e.g. stirring of bioluminescent bacteria by a swimming fish, or active, e.g. use of light organs (photophores) for communication. Bioluminescence is also used as camouflage. A fish in midwater casts a shadow in the downwelling light during daytime. A variety of fish use bioluminescence on their bellies to fill in this shadow and become invisible to predators below them if the emitted light matches the downwelling light in intensity and spectral composition. Last but not least, fish use bioluminescent lures to attract and capture prey. The abundance of bioluminescence in the ocean has led to various amazing adaptations.

Definition of tasks

The diversity of visual capabilities in marine organisms offers countless opportunities to use light for making fisheries more effective and selective. For efficient use of research resources, the users have to identify species and problems where better biological understanding is needed to achieve significant improvements. However, the Biology group itself may also suggest species or problems to be studied as its members have specific experiences unavailable to the users. Furthermore, other theme groups in the Artificial Light Topic Group may need answers to specific questions. Information has to be exchanged with the users and within the topic group in order to identify the most promising areas of work.

Sharing of information (Required inputs)

All existing knowledge of the target species and the fisheries performed are of high value for guiding the scientific studies. Fishermen are in close contact with the target (and bycatch) species. They make many useful observations and have long-term experiences. All information on observed physiological reactions, such as pupil constriction/dilation, changes in body coloration, catatonia in bright light or darkness etc. should be passed on in order to avoid unnecessary duplications of efforts.

Identification of relevant parameters is a major challenge as the animals live and use their senses in a world unfamiliar to humans. Any information on the physical, chemical and biological environment at the harvesting site and time may be of importance. Specifically, a description of optical properties of the water during the capture process (i.e. attenuation coefficient and variations of it with time, including scattering and absorption coefficients) as well as parameters that may affect the visual capability and behavioural responses of the target species (e.g. temperature; salinity; oxygen content; turbidity; time of day/season; weather conditions; other stimuli). It is therefore recommended to develop standards for collecting such information and routines for making it available to the involved research institutions.

Information on the light stimuli being used (if applicable) is necessary in order to identify possible improvements; specifically, a description of the light field (with respect to wavelength, irradiance, radiance and polarization) at various ranges from light source.

<u>Outputs</u>

- Review of scientific literature - The scientific literature may contain information useful in fisheries. If a problem is defined, scientists familiar with the literature can extract the information necessary for improving fishing methods.
- Review of the available methods,
  - Limitation
  - Output
- Visual perception of target species
  - sensitivity to different wavelengths (spectral sensitivity),
  - colour contrast,
  - polarized light,
  - stationary and moving patterns (temporal and spatial resolutions),
  - contrast (intensity and polarization) thresholds with varied intensities and polarizations and

    - models of vision (to be combined with models of the visual environment) in order to determine the visual information available to the animals.
- Suggestions on optimal parameters for
    - Selectivity (e.g. use the faster vision of marine mammals to separate them from fish/squid/crustaceans; use the higher visual resolutions of fish to separate them from shrimps).
    - Attraction (e.g. optimal lighting for attracting target species to pots).
    - Impact reduction and quality improvement (e.g. use moving patterns to guide fish into/out of trawls, nets, and traps).
    - Energy conservation (minimize intensity and spectrum of light used).

Materials, Methods and Facilities

- Field studies
    - Basic biological parameters (e.g. size ranges, stomach contents, environ-mental parameters, fish behaviour).
    - Visual parameters (e.g. visual pigment absorptions, optical properties).
    - Physical parameters (e.g. temperature, turbidity, coloration).
    - Collection of material for laboratory studies.
- Laboratory studies
    - Eye and retina morphology (visual resolution).
    - Differences between light and dark adapted animals.
    - Visual pigment genes and their regional expression in the retina.
    - Visual fields and regional specializations (many animals have acute zones of particularly high resolution and/or regional differences in colour and motion vision).
    - Speed of vision (e.g. critical flicker fusion frequency, optomotor response).

Physiological studies generally require access to fresh material, in many cases even living animals. Studies on the visual sensitivity and optical properties of fish eyes, for example, have to be performed within 30 min after the death of the animal. In most cases, it is easiest to bring the equipment and the researchers to the animals and not *vice versa*, as transport and keeping times and conditions may lead to compensatory changes in the animals. Some studies can be performed onboard fishing and research vessels, while more advanced methods require laboratory and fish keeping facilities. Meeting the requirements of any particular study is a factor that has to be taken into account in the planning phase. Experience has shown that it is often worthwhile to develop portable set-ups for measurements on site.

Suggested Areas of Research

Two different approaches are envisioned:

- Firstly, the gradual improvement of existing methods with the aim of higher energy efficiency and fishing selectivity; and

- Secondly, the design and testing of entirely new ways of using light stimuli.

Better understanding of the visual capabilities of target species can lead to immediate improvements. For example:

- *How does light attract squids?* - White LEDs are tested as energy-efficient light sources in squid jigging. However, the target species are probably most sensitive to blue-green light (about 480 to 500 nm in wavelength) as these wavelengths penetrate deepest into clear ocean water. White LEDs emit little light in this spectral band, such that using blue-green LEDs appears to be a promising approach.

Knowledge of the visual capabilities of a species may make it possible to control their behaviour in fishing operations. For example:

- *May light be useful to lure cod into pots?* Knowledge of the use of light and its perception by marine organisms may allow fishermen to tune in on the communication channels used by the animals and lure them into fishing gear (target species).
- *Do the visual systems of different marine organisms have properties that may be exploited to make trawls more selective?* Likewise this same knowledge of the communication channels of the animals may be used to warn and repel them (bycatch species).

Differences in the visual capabilities of target and bycatch species may lead to more selective fishing methods. For example:

- *Are the visual systems of fish and shrimp so different that visual stimuli may be used for separation?* Shrimp and krill tend to have considerably less acute vision than fish, such that it should be possible to design visual stimuli that can be perceived by fish, but not by the crustaceans.

9.6.5 Behaviour

Light fishing techniques typically use an artificial light stimulus to induce some form of behavioural control/manipulation over a target species to facilitate its capture. A thorough understanding of how the target species will respond to the light stimulus is therefore critical to the success of any capture method using artificial light.

The reaction of animals to light can be classified into four categories: Attraction (positive reaction), repulsion (negative reaction), neutral (no response) and catatonia (immobilization or stupor). As with any behavioural response to a stimulus, the response to artificial light may be predictable to some degree but will also be modified by additional stimuli and ecological factors, for example:

- Environmental conditions (e.g. temperature, salinity, water movement, natural light)
- Optical properties of the water (i.e. turbidity, refractive indices, scattering and absorption (attenuation) coefficients)
- Received light stimulus (i.e. resulting from attenuation of emitted light)
- Conflicting stimuli (e.g. noise, chemosensory, predatory threat, natural light)
- Status of target (i.e. biology, age, sexual maturity, hunger, injuries/disease/parasitism)

This group will consider the research required to describe and interpret the behavioural responses of the target species to an artificial light source, in context with these behavioural modifiers. Such research will build on the description of the light produced by the artificial light source (C.f. the Engineering Group), how this propagates through the water (C.f. the Optics Group) and what the visual capabilities of the target species are (C.f. the Vision Biology Group), to enable these behavioural responses to be manipulated to promote the sustainable capture of the target species.

Required Input

1) Define the issues and research questions (i.e. the target species and the characteristics fishery, including any bycatch and ecosystem effects issues).

2) Knowledge from fishermen (i.e. field observations)

3) Physical and optical conditions at catching site (i.e. light intensity and light composition, temperature, optical properties of the water)

4) Visual pigments, lens properties and ability to see polarized light

5) Predator prey info (stomach contents, its prey and predators –and knowledge of natural behaviour related feeding behaviour and anti-predator behaviour; i.e. what triggers an attack – line fishing)

6) Light threshold for schooling behaviour and other known behavioural parameters

7) Circadian phase, seasonal changes (i.e. difference between light condition in polar cod and Atlantic cod’s seasonal light conditions)

8) Alternative/conflicting stimuli: water movement (currents); noise; conflicting/competing light sources (i.e. other vessels, the moon/sun, etc.); presence of potential prey/predators; feeding status of target species; reproductive status of target species; physiological status of target species;

9) Video of behaviour in gear in field – if available

10) Availability of LED Light (or other low powered light sources) at wanted wavelength and intensity

11) Camera (engineering – enhancement of light sensitivity and visual quality of recordings)

12) Speed up of Video analyses, (automate to pick out fish activities and cut recorded parts of no interest)

<u>Experimental fish for lab and mesocosm studies:</u>

Physiological condition of caught fish, light and optical condition in their natural environment (where caught)

<u>Mesocosm or fish cage</u>

To hold pelagic fish (herring, mackerel, sprat, squid(?))

To be used to test out visual ability and behaviour of pelagic species

(i.e. optomotor and optokinetic responses, feeding and anti predator behaviour).

<u>Swim tunnel facilities</u>

To be used to test optomotor response or black tunnel response

– relevant to test out possibility to controlling fish movement in a trawl (i.e. testing if sequential fleshing light from the front towards the codend could make fish turn and swim towards the codend, and by that hit the selection devise close to or at the codend before being totally exhausted)

Large and smaller tanks and flume tanks

Test out natural strike/escape behaviour (i.e. first important for line fishing later for trawl and traps). Control for state dependence (hunger, condition, sex, age, time a.s.o.).

Outputs

1) Fish, shrimp and squids behavioural response to light stimuli of different intensity, wavelength, polarization and flickering.

   Behavioural response: no response, attraction, repulsion or catatonia.

2) General features of the studied species behaviour.

3) Species-specific knowledge of behavioural responses.

4) Input to behavioural models.

Methods

Tested stimuli:

Behavioral response to effects of static, flashing, flicking and moving lights.

Light will be presented in different wavelengths and grade of polarization.

Studies will be performed in:

Lab experiments – mesocosms and field, depending on the species and its physiological restrictions

Experimental methods:

Optomotor and/or optokinetic response (lab and mesocosm)

Conditioning test (test for sensory capabilities, if optomotor resp. do not work)

Field studies: to control the findings from the laboratory and mesocosms

Studies

Suggested Research

A) Defined problem: Shrimp trawling fisheries large by catch

Worldwide problem – separate shrimp (or nephrops in EU) from fish (bycatch).

Rational: Crustaceans have compound eyes – thus they should have a spatial resolution lower than fish, but a higher temporal resolution.

Possible solution: Guide the fish out of the trawl (through openings in top or side of trawl) by exploiting these differences in special and temporal resolutions, for example by presenting patterns of high spatial resolution to induce an optomotor response in fish.

B) Defined problem: trawling can have large negative impact on some bottom habitats and communities

Rational: some species targeted by trawls are known to be attracted to lights (e.g. cod, shrimp, squid).

Possible solutions: Use low impact gears (e.g.. fish pots) in combination with lights to selectively target these species.

9.7 Recommendations

The Topic Group should continue to work by correspondence in 2013/2014, with the aim of addressing the current terms of reference and presenting a draft report to the plenary session of ICES/FAO WGFTFB in 2014.

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10 ToR c): Relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries

10.1 General overview

The aim of the ToR C is to assess a series of relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries, in order to establish maximum dimensions and adequate rigging for trawl fishing gears. All these elements will contribute to improve the selectivity, to limit the fishing effort and to minimize the environmental impact of fishing gears. Such information can be useful to evaluate the potential harvesting pattern of different gears in terms of explored area during fishing operations and thus contributing to specific management measures of fishing capacity. Empirical relationships among different parts of the fishing trawl gears, including different type of likely attachments, as well as between some of these parts and the otterboard size and the engine power of the vessel shall be reported. The data collection must be carried out on the basis of the information collected and/or measured in relevant Mediterranean fishing fleets with the collaboration both of the fishing sectors and of the control/inspection bodies. Information must also be independently collected through the fishing-nets makers, door manufacturers and when possible fishermen. Literature information as well as results from research projects and studies, funded either with national or/and EU support, must be used in view of establishing synergies among different scientific domains while avoiding duplications.

10.2 List of participants

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10.3 Discussion

The session was configured as a unique roundtable. Antonello Sala introduced the project MyGears (http://mareaproject.net/contracts/8/overview/), a European research project which aims at collecting updated information on the characteristics of trawlnets used in different Mediterranean fisheries. In Figure 11, the layout and main goals of the MyGears project are shown. On the basis of literature review and direct in-situ measurements, a collection of data regarding trawl gear parameters such as net drawing, headline and footrope length, door size, vessel main characteristics etc.

is carried out. Dataset so obtained allows for the definition of preliminary statistical models which are further improved by literature review on fishing gear modelling and analysis (e.g. Fridman *et al.*, 1986).

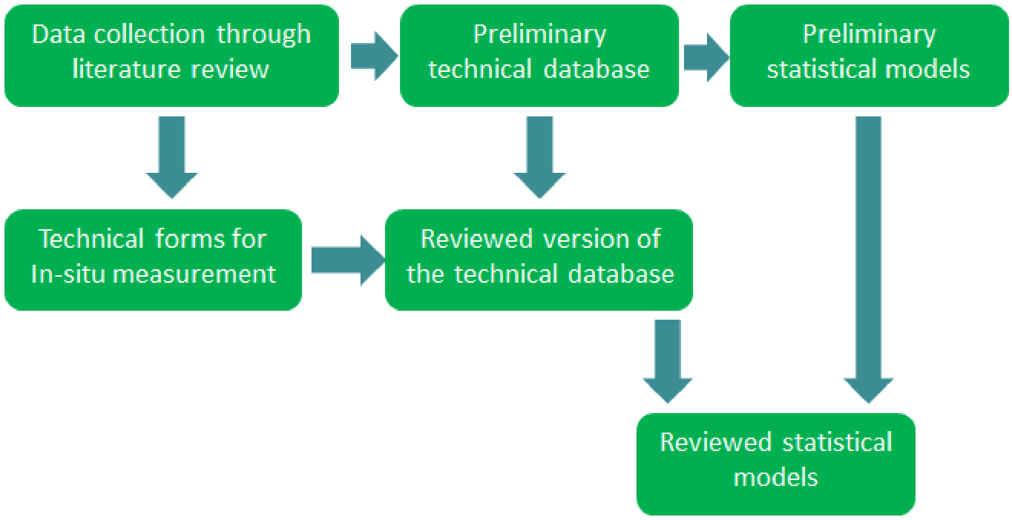

Figure 11. Project MyGears layout. Main goals of the project are a complete data archive for trawl gears in the Mediterranean Sea and models to relate major components of the gears and to relate the gear with the vessel.

According to the specific objectives of the project the following outcomes have been achieved:

- collection of information from various literature sources (e.g. peer review as well as grey literature, reports, etc.), relevant to describing the different types of Mediterranean trawl gears and fishing vessels;
- identification and selection of appropriate gear metrics to be used in the direct measurement of the size of nets and in the examination of the relationships between gear and vessel metrics;
- collection and harmonization of the collected information obtained from literature review into a database that can be used as a first basis for quali-quantitative analysis, and decision support.

Data collected by project partners throughout literature review and direct in-situ measurements are processed by the same database that allows for dynamic parameters simulation (e.g. horizontal net opening, door spread, gear drag etc.) on the basis of geometrical and mechanical information inserted (Figure 12).

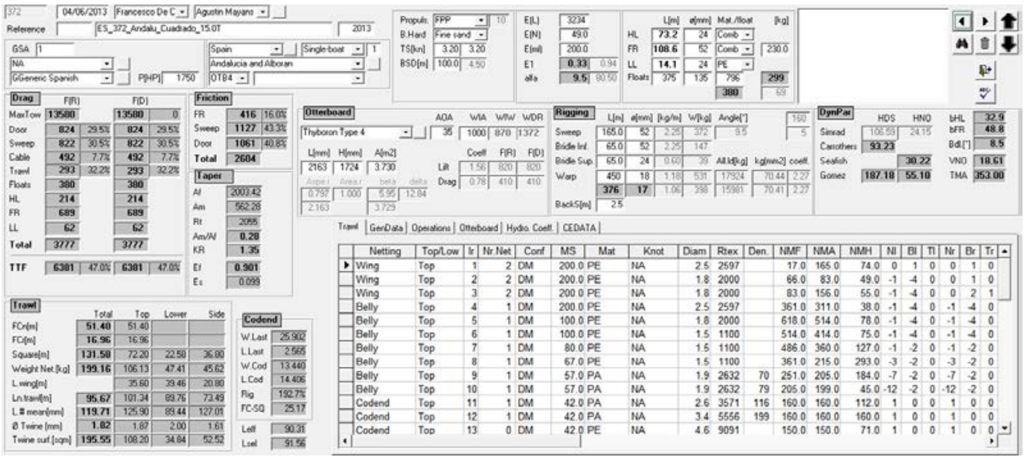

Figure 12. Snapshot of the data collection software.

Data analysis takes into account the heterogeneity of Mediterranean fisheries. The same trawl technique, carried out with the same typology, can be quite different depending on area, different behaviour and knowledge of fishermen, differences in sea conditions and seabed etc. For this reason trawl typologies have been clustered in different areas and subareas (Figure 13, Figure 14).

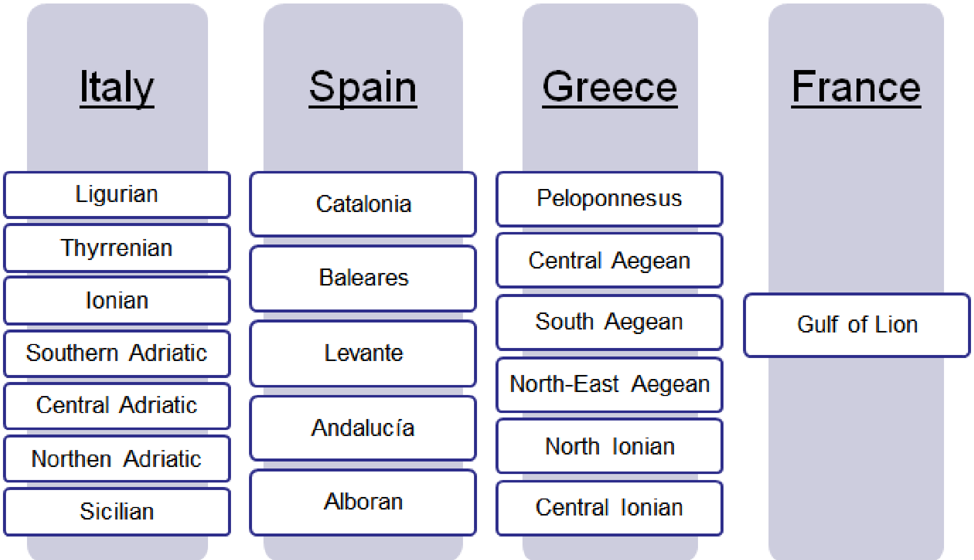

Figure 13. Areas investigated. Each country considered is subdivided in many subareas for a deeper analysis of the trawls specifications.

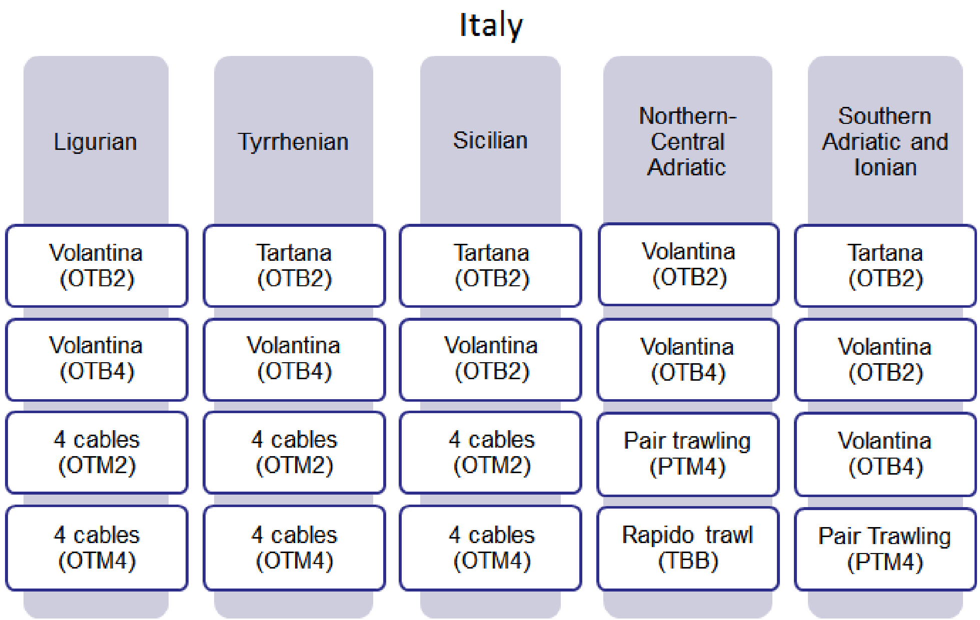

Figure 14. Areas and subareas for Italy. Same trawl typology (e.g. OTB2, OTB4, PTM4 etc.) could highlight some minor difference among different subareas, so that it is necessary to separate those data.

10.4 Main Outcomes

The huge variety on fishing gear characteristics on one hand and the need of EU to assess management tools for handling overexploitation of the European Seas make challenging the definition of standard parameters for fishing gears. Fishing gears for the same fishing technique among different countries, and stock areas can be quite different, mainly due to different specifications in design and materials used. Different depth, seabed and other environmental characteristics seem have an influence on different trawl gear design. Despite the availability of innovations in fishing gear design, technology in many areas still remains at a traditional level. There is the need of a methodological approach in order to highlight best relationships among major gear parameters and between gear and vessel.

10.5 Recommendations

Following the discussion, a list of recommendations was provided:

- Fishing gear technology needs a methodological approach, in order to standardize methods and results of data collection, analysis and performance evaluation;
- Methodological approach should consider also terminology, as different areas can use different terms and meaning for same objects.

11 ToR d): Incorporation of Fishing Technology Issues/Expertise into Management Advice.

11.1 Introduction

In 2012, a discussion was held within the WG on continuation of this ToR. It was reported that the Advice groups within ICES found this information useful, and desired its continuation, and the value of connections across WGs was emphasized. In the past, responsibility for producing the advice, in the form of individualized reports to different WGs, fell on the ICES chair and the previous ICES chair, and required a great deal of time during and just after the meeting. In addition, WG members found some of the information duplicative with National Reports and in previous years. It was suggested that a new group member should come forward to assume this responsibility.

Prior to the meeting in 2013, the previous chair informed the ICES chair that he was unable to produce the individualized reports. In light of this absence, the ICES chair did not solicit this information from the WG. At the meeting, he described the reasons for the absence of the term of reference. Acknowledging that the advice is valuable, the chair suggested that the ToR become biannual, and that the role of the previous chair in producing the reports be taken on by a new WG, with involvement in the EU-ICES assessment process. No volunteers were identified at the meeting.

11.2 Recommendations

- The current or a modified questionnaire should be distributed among members every two years.
- WG member(s) should be identified to supplement or replace the previous chair who tailored advice for individual assessment groups.

12 National Reports

12.1 General Overview

Participants were asked to prepare summaries of current and expected research related to the activities of the WG within their country prior to the meeting. Twelve National reports were produced: Argentina (first contribution in recent memory), Canada, France, Iceland, Ireland, Italy, Japan, Netherlands, Norway, Scotland, Sweden, and the United States. The full text of these reports is inserted below, by country. The chair presented a summary of some of the major themes crossing nations during the meeting. A word cloud was produced from the full text of the National Reports as a means of concisely and simply summarizing the main areas of interest in the reporting countries (Figure 15). The word cloud displays words in font sizes proportional to their frequency within the text – the bigger the word, the more frequently it appeared in the reports. The word counts are also displayed in parentheses. Not surprisingly, words such as “catch”, “fishing”, “fisheries”, and “project” were common. Two words whose prominence increased from previous years were evident: “bycatch” and “fishermen”. The only species name that appeared was “cod”. Consistent with prior experience, “trawl” was the most common gear seen in the cloud.

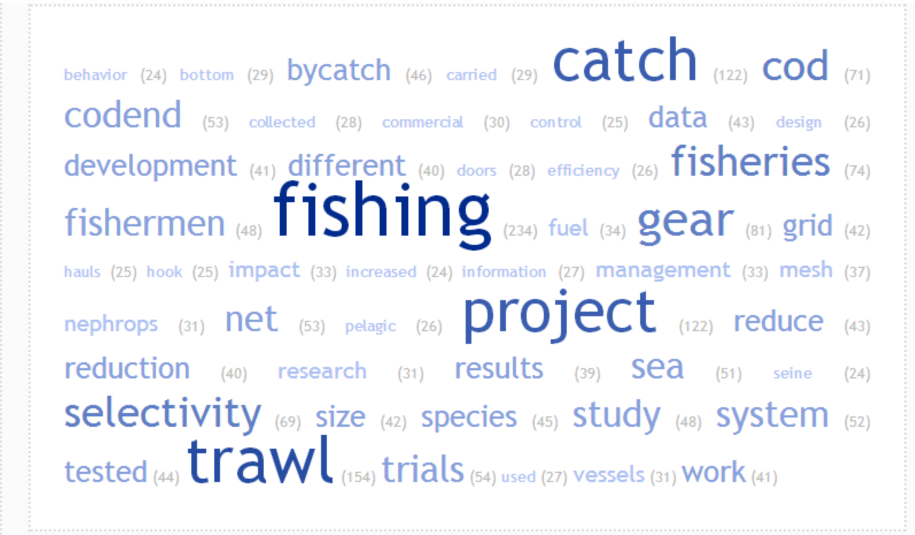

Figure 15. Word cloud of the text of all national reports. Word size is proportional to its frequency; counts are reported in parentheses next to each word.

The contents of the individual National reports are NOT discussed fully by the group, and as such they, and this summary, **do not necessarily reflect the views of the WGFTFB**. Eight themes were identified and are used below to summarize the overall research. It is recognized that projects can belong to multiple themes, and that the themes are not independent. For example, “energy efficiency” and “environmental impact” are intimately related. Separation of themes is used for summary purposes only, and to allow WG members to uncover potential collaborations or additional data within the WG. The summary is not meant to be comprehensive – it is meant to encourage full reading of the National Reports.

Behaviour and Physiology was strongly represented in the year’s reports, with projects reported by Canada, Japan, Norway and the US. Notably, Japan reported several broad based efforts to investigate swimming performance, visual physiology, and fish movement, including methodology, and underwater video monitoring of the capture process. The need for expanded work in these areas has been emphasized repeatedly by the WG as a way of building our fundamental understanding of the fish capture process, and the reporting of so much work in this area was lauded.

Research into pots and traps was surprisingly common, as this gear type was until recently fairly marginal and considered an "alternative" gear. Eleven projects were reported from Canada alone. Research ranged from basic development to improved selectivity in size and species. Pot research is expanding with new target species such as Greenland halibut, red porgy, and white hake identified. Concerns over ghost fishing gear motivated at least two projects. A rather extensive program of comparison of fishery outputs targeting Nephrops with trawls v. traps was underway in France.

Energy efficiency continues to stimulate a great deal of research, likely in reaction to increases in fuel prices. Interest was wide-spread and on a variety of scales, including broad-scale projects to propose rational fishing strategies for entire sectors, or to assess fleet fuel consumption. Even a return to partial use of sails was reported in Canada, and an innovative semi-pelagic door financing model where the doors paid for themselves through fuel savings was developed in the US.

Reduced environmental impact and energy efficiency are linked, and several projects overlap these themes. The use of electricity continued to expand, especially in the Netherlands. Several project focused on lifting or lightening components of trawls, with doors a specific area of development, reflecting a continuing interest in migrating from demersal to pelagic and semi-pelagic trawl gears.

Research on trawls and dredges beyond impact and fuel efficiency was common and was reported in three sub-categories: shrimp; modelling; species and size selectivity. Argentina, Canada, Sweden, and France reported studies related to improving species selectivity, efficiency, or quality for crustaceans. Three or four separate projects in Canada, France, and Norway were examining modelling of fishing gear. Two selectivity projects were examining selectivity at the sub-haul level. Many, many projects were investigating species selectivity in a variety of methods.

12.2 Argentina

Contact: Ricardo Roth (rroth@inidep.edu.ar); Julio García (jgarcia@inidep.edu,ar), National Fishery Research and Development Institute (INIDEP).

Selectivity on hake (*Merluccius hubbsi*): feasibility study in the development of soft selectivity devices in shrimp fishery

The possibilities of hake escapement in voluntary basis by means the use of soft devices in shrimp fishery trawls are under study. First trials were carried out (2008) with a behaviour fish device, creating different water flow speed that stimulated the fish sorted out the trawl through an exit hole. Trends showed an increase of hake escapement, mainly juveniles, when trawling speed decrease. Further studies will be carrying during 2013.

Grids for Hake selectivity design by fishermen

Several grids were tested in hake fishery with the aim of reduce the catch of juveniles. New grid device design was presented by fishermen in order to be tested by Fishing Gear Group. A survey will be carrying out in order to get selectivity parameters.

Studies in gillnet selectivity

Several trials will be carry out in Patagonian smooth-hound (*Mustelus schmitti*) fishery in order to obtain selectivity patterns from fishermen gillnets.

Selectivity studies in scallop (*Zygochlamys patagonica*) fishery

Fishing gear efficiency and selectivity parameters of commercial bottom trawls will be estimated.

Collapsible fish traps for red porgy (*Pagrus pagrus*)

Assessment the catch of red porgy by means a new design of collapsible traps with double side entrance.

Fuel efficiency in trawls

The starting point will be after the meeting ICES-FAO WGFTFB 2013 in Bangkok. The project shall propose new rational fishing strategies and develop new, feasible gear concepts in close cooperation with fishers and the fishing industry, through workshops, lab tests and numerical simulations, including aspects such as net design, towing resistance and catch efficiency.

12.3 Canada

12.3.1 Fisheries and Marine Institute of Memorial University of Newfoundland

Detecting Lost Crab Pots Using Sidescan sonar

Tens of thousands of crab pots are lost each year in Atlantic Canada. We conducted a brief feasibility study to determine whether (intentionally) lost pots could be detected in deep water using a towed sidescan sonar. Preliminary results were encouraging. We demonstrated that sidescan sonar can successfully detect crab pots at depths up to 215 m and a maximum across track range of 130 m when the tow fish was situated 40 m from the seabed. To our knowledge, this is the first time sidescan sonar has been used to detect crab pots at significant water depths. Contact Paul Winger (Paul.Winger@mi.mun.ca).

Snow Crab Behaviour in Response to Approaching Trawl Footgear

The objective of this study was to conduct trawl-mounted video camera observations of snow crab interacting with the rock-hopper footgear components of a traditional shrimp trawl. The goal was to provide insight into how individual crabs interact with footgear components. Specific parameters measured included position, size, orientation, reaction behaviour (direction of movement), and nature of collision (duration and fate). The results of the video analysis revealed that approximately 53% of the crabs observed experienced a collision with the footgear (either disc or spacer/chain) and that the majority of these collisions were < 1 second. Contact PhD student Truong Nguyen (Truong.Nguyen@mi.mun.ca).

Simulation vs. Flume Tank

Few examples exist in which the accuracy and precision of numerical and physical modelling techniques have been compared to full-scale trawl performance at sea. A project is currently underway to statistically compare 3 datasets (numerical vs. physical vs. full-scale) for the Campelen 1800 survey trawl. We hope to discuss the merits/limitations of each approach and how each can assist the gear development cycle. Contact PhD student Truong Nguyen (Truong.Nguyen@mi.mun.ca).

Energy Efficient Shrimp Trawls

Two projects recently investigated methods of reducing fuel consumption during inshore shrimp trawling activities in Newfoundland. We tested the feasibility of shortened bridles, reduced twine diameters, modified footgear, increased mesh size, and improved trawl door design, all as means for reducing hydrodynamic drag and saving fuel. The work was conducted under the controlled conditions of a flume tank using scaled engineering models (1:4, 1:8, 1:40). Full-scale sea trials were conducted in 2011 and 2012. Contact George Legge (George.Legge@mi.mun.ca) or Harold DeLouche (Harold.DeLouche@mi.mun.ca).

Reducing Seabed Impacts of Bottom Trawls

A five year project is currently underway with Vónin to develop bottom-trawl technology capable of catching commercial quantities of finfish and shellfish with reduced seabed contact compared to traditional systems, thereby reducing significant environmental impact on the seabed. The objectives of the project are to conduct computer simulation of innovative fishing systems; evaluate physical models using the flume tank; and construct and evaluate full-scale prototypes. Contact Paul Winger (Paul.Winger@mi.mun.ca).

Twin-Trawling for Inshore Shrimp

A project was initiated in April to develop twin-trawling technology for the inshore shrimp fleet (375 vessels) in Newfoundland and Labrador. A combination of numerical modelling, flume tank trials, and at-sea demonstrations are planned for 2013. Contact Harold DeLouche (Harold.DeLouche@mi.mun.ca).

Biodegradable Twine

Use of the biodegradable twine will become mandatory in 2013 for the snow crab fishery in Newfoundland. An experiment was conducted to evaluate the best natural fiber (cotton, hemp, jute, and sisal). A total of five twines were evaluated in field trials, covering a period of 124 days at liberty. The 96-thread cotton twine performed the best. Compared to the other twines evaluated, the rate of degradation for this twine was relatively quick, with a 33% reduction in the initial breaking strength recorded after 64 days, and a total reduction of 63% of the initial strength upon conclusion of the study at 124 days. Adoption of this technology should significantly reduce ghost fishing. Contact Paul Winger (Paul.Winger@mi.mun.ca).

Turbot Potting

A study is underway to determine whether baited pots can be used to capture commercial quantities of turbot (Greenland halibut). The project is being carried out in deep water channels on the northeast coast of insular Newfoundland. Sea trials will continue this summer (2013). Contact Scott Grant (Scott.Grant@mi.mun.ca).

Hake Potting

A study is currently underway to develop baited pots for white hake (*Urophycis tenuis*). The discovery that hake will enter baited pots was accidentally made during a potting project for Northern stone crab in 2012. It builds on the earlier success of cod potting and there is hope it might lead to an alternative sustainable harvesting strategy for this species. Comparative fishing experiments, including Norwegian pots designs, are planned for September 2013. Contact Philip Walsh (Philip.Walsh@mi.mun.ca).

Greenland Shark Bycatch Reduction – Longline Modification:

A multiyear study has been initiated to investigate the feasibility of longline modifications to reduce the bycatch of Greenland shark in Nunavut's (Canada) Cumberland Sound turbot fishery. The primary objective is to test the ability of 1) various gangion breaking strengths, 2) gangion length, and 3) the interval between gangions to reduce the capture and/or entanglement of Greenland shark in turbot longline gear without reducing the catch rates of turbot. Year 1 and 2 results were encouraging. Additional sea trials are planned for summer 2013. Contact Scott Grant (Scott.Grant@mi.mun.ca).

Greenland Shark Bycatch Reduction – SMART Hooks

Experiments were conducted to test the ability of SMART hooks (®RepelSharks; i.e. selective magnetic and electropositive alloy treated hooks) to prevent predation upon baited hooks and subsequent capture and/or gear depredation (i.e. damage to longline gear, bait, and turbot) by Greenland shark. All six Greenland shark captured during the experiment were taken on SMART hooks (5 of the 6 sharks) or in the SMART hook 20 hook replicate (1 of the 6 sharks) of the experimental longline. Further, behavioural observations revealed Greenland shark did not exhibit the typical avoidance response to a clump of electropositive alloy removed from seven of the SMART hooks. Overall, these results indicate SMART hooks are not a practical solution to reducing the bycatch of Greenland shark in Nunavut's (Canada) turbot longline fisheries. Contact Scott Grant (Scott.Grant@mi.mun.ca).

12.3.2 Fisheries and Oceans Canada Central and Arctic Region

Greenland Shark and Arctic Skate Bycatch Reduction – Pot Traps

A multiyear experiment was initiated in 2010 to test alternative gears that could be used to reduce shark and skate bycatch in the Cumberland Sound Greenland halibut fishery. Currently, the fishery exclusively uses bottom-set longlines and primarily catches Greenland Shark and Arctic skate as bycatch. In 2010, three pot traps based on the design of the Alaskan cod pot were built and tested in Cumberland Sound as a pilot project. In a limited number of sets, the pots caught Greenland halibut and did not catch either Greenland sharks or Arctic skates. In 2012, additional pot traps will be built and tested in a full experiment to assess differences in catch rates and the commercial viability between longlines and pot traps in the Cumberland Sound fishery. Contact Kevin Hedges (Kevin.Hedges@dfo-mpo.gc.ca).

12.3.3 Merinov, Centre d'Innovation de l'Aquaculture et des Pêches du Québec

Controlling bait costs in Lobster and Snow Crab fisheries in Québec

The main objective of this research program is to find some solutions to reduce the cost of bait in crustacean fishing pots fisheries. Secondary objectives are: 1) to increase our knowledge of traditional practices in different fishing areas in Québec; 2) to develop alternative bait based on fish processing by-products and evaluate their effectiveness in terms of fishing yields; and 3) to involve the fishing industry in the innovation process and facilitate the technology transfer. Contact Jérôme Laurent (jerome.laurent@merinov.ca).

Kite Sail on a Shrimp Trawler

This project consists of installing a kite sail on a shrimp fishing vessel to reduce the fuel consumption. The first step of this two year project will be related only to the installation and the optimization of the kite system onboard. Launching and recovering operations and security tests will be performed. During the second year, comparative at-sea trials will be performed to quantify energy savings. In addition, navigational data (fuel consumption, RPM, boat speed, etc.) and environmental data (wind force and direction), will be recorded the entire fishing season. Specific care will be given to safety and security. Contact Damien Grelon (Damien.grelon@merinov.ca).

Codend development: enhancing filter efficiency and shrimp quality

A project will be carried out in 2013 to compare traditional and experimental codends for shrimp trawls, using the twin-trawling approach. The goal is to reduce net drag and enhance shrimp selectivity. A combination of numerical modelling, flume tank trials, and at-sea demonstrations are planned. Contact Damien Grelon (Damien.grelon@merinov.ca).

Modification of Rock Crab Pots to Increase Selectivity

Rock crab is harvested using conical pots that are not very selective and in some areas, a not-insignificant quantity of lobster ends up as bycatch. In 2012, a study was carried out to study the performance of a selecting device in rock crab pots. This one is made of a disk with two slots through which rock crabs can enter the cage but not commercial size lobster. The device is installed at the base of the entrance cone and is hinged. Thus, it is easy to add bait. The goal of the project was to assess the impact of the modification on on-board work time, compare the number of crabs caught in modified traps to catches using conventional traps, and compare the effect on bycatch. Contact Damien Grelon (Damien.grelon@merinov.ca).

Development and introduction of a lobster slide

Female lobsters with eggs need more precaution when they are thrown overboard. Loss of eggs may be very important depending on how lobsters fall in the water. The side of lobster vessels is sometimes high (up to 3 feet) and the workable area is far from the water surface. The objective of this study is to work with fishermen to develop a slide that enhances the safe return of female lobster to the ocean. Some sea trials will follow. Contact Damien Grelon (Damien.grelon@merinov.ca).

Thyborøn Pelagic Door on Bottom shrimp trawling with ACPG Innovation

In 2012, a fishing system equipped with Thyborøn15VF semi-pelagic trawl doors was adapted and installed on two Québec vessels engaged in the Gulf of St Lawrence shrimp fishery. Two fishing trips were conducted in summer 2012 with two vessels fishing side by side to evaluate and compare the fuel consumption and catch performance of a vessel equipped with 15VF "flying" doors with those of a vessel equipped with conventional bottom doors. The data gathered showed that the flying doors generated fuel savings of 7 per cent on average. As for the catches, no statistical differences in terms of either fishing yield or size structure were seen. This project also showed the importance of monitoring the trawl which allows the skipper to continuously adjust settings to conserve the ideal fishing configuration. Contact Antoine Rivierre (Antoine.rivierre@merinov.ca).

PDG 2: Reducing impact of Scallop Dredges on seabed

The main objective is to provide recommendations on possible changes to the scallop dredge and fishing practices in order to ensure sustainable harvesting. More specifically, we will want to: 1) determine the impact of dredging on the seabed; 2) describe the swimming behaviour of scallops in front of the dredge; and 3) assess the proportion of scallops that avoided dredge, in relation to factors like water temperature and the reproductive cycle of the scallop. Contact Lisandre Solomon (Lisandre.Solomon@merinov.ca).

Feasibility study for a deep-water whelk fishery on the North Shore

This study was conducted in September 2012 in two areas. Three different traps (Portzic, 8-inch and 17-inch) were tested in three different depth ranges (from 20 to 40 fathoms, from 41 to 70 fathoms and from 71 to 90 fathoms). Several variables were measured, including the number of commercial- and sub-commercial sized whelks. In addition, all bycatch species were identified, counted and measured. Analysis of all the data gathered appears to show that the 8-inch trap performed best. However, the Portzic trap produced a good yield and appeared to keep bycatch to a minimum. Contact Sandra Autef (Sandra.autef@merinov.ca)

Reducing Seabed Impacts of Mobile Fishing Gears:

The main objective of this proposal is to develop an innovative shrimp trawl for the inshore fishery in Québec. Specific objectives are related to improve energy efficiency and reduce environmental impact of trawling. Contact Antoine Rivierre (Antoine.rivierre@merinov.ca).

Evaluating the effectiveness of a lightened sea cucumber drag:

The main objective of this project is to determine the capture efficiency of a light skidding dredge designed for fishing sea cucumber, in a new fishing area in Middle North Shore of Quebec. Four specific objectives are identified: 1) assess the catch per unit of effort (CPUE); 2) determine selectivity toward juvenile's sea cucumber and non-target species; 3) describe the nature of the seabed and the impact on the fishing gear performance; 4) identify changes in fishing gear and to make adjustments to improve the capture efficiency. Contact Sandra Autef (Sandra.autef@merinov.ca).

12.3.4 Simon Fraser University and Vancouver Island University

Underwater Camera for the Study of Trapping Gear

A low-cost camera apparatus (dubbed TrapCam) was developed to study trapping gear *in situ*. The apparatus was constructed with off-the-shelf parts, and at a cost of ~$3000 was able to record 13-hour videos in full HD (1080P) at depths up to 100 m. The apparatus was specifically designed to be quiet and non-invasive, making it ideal for studying behaviour of marine species in and around trapping gear. This apparatus was designed in order to study traps designed to catch spot prawns (*Pandalus platyceros*) in British Columbia, but could be adapted for other purposes. Design schematics and sample videos are included online. Contact Brett Favaro (bfavaro@sfu.ca).

Bycatch Reduction Devices for Spot Prawn Traps

A suite of detachable bycatch reduction devices (BRDs) were designed and built in order to prevent the bycatch of juvenile rockfish (*Sebastes* spp.) in commercial spot prawn (*Pandalus platyceros*) trapping gear. These devices were curved, multi-ringed openings which clipped to the inside of the traps, and were designed to facilitate prawn entry while excluding rockfish. Field trials revealed that these devices were highly effective at excluding rockfish and other fish, while simple reductions in trap opening sizes were ineffective in this regard. However, the curved tunnel BRD's also produced a reduction in prawn catch relative to control traps, suggesting that further refinements in the design are necessary before implementation in the fishery. Contact Brett Favaro (bfavaro@sfu.ca).

12.3.5 Dalhousie University and WWF-Canada

Shark Bycatch Reduction in Canadian Pelagic Longline Swordfish Fishery

Deterrent hooks with electropositive metals (neodymium/praseodymium, Nd/Pr) were tested on pelagic longline gear typical for targeting swordfish. The electropositive metals oxidize in seawater and create electric fields, which can alter the swimming and feeding behaviours of several species of sharks, and have the potential of reducing predation and bycatch rates. We tested the null hypothesis that electropositive metals do not reduce shark bycatch or target (swordfish) catch. A total of 7 sets (6300 hooks) were deployed in 2011 on the Scotian Shelf in the Northwest Atlantic. For blue sharks and all sharks combined, no significant differences were observed between the treatments whereas the swordfish catch was significantly reduced (by 48%) on the hooks treated with the Nd/Pr. The results of this study show that electropositive metals do not present a practical bycatch mitigation measure for the Canadian longline fishery. Contact Aurelie Cosandey-Godin (godina@dal.ca).

12.4 France

12.4.1 Ifremer Fishing gear technology laboratory

Contacts: Gérard Bavouzet (gerard.bavouzet@ifremer.fr), Pascal Larnaud (pascal.larnaud@ifremer.fr), Benoît Vincent (benoit.vincent@ifremer.fr).

"Deepsea" EU project: reducing the impacts of deep fishing trawls

Deepsea EU project aims at reducing the impact of deep fishing trawls and reducing there discards. We develop and test a trawl with off bottom foot gear (and a light gear option). The engineering parameters of this trawl are assessed by the mean of simulation, tank trial and sea trials. The reduction of discards is undertaken by the mean of spacio-temporal and practices strategy. The coordinator of this projects is COFREPECHE and SCAPECHE is the industrial partner. Trials in Lorient flume tank were realized to confirm the data acquired with DynamiT software.

"Jumper" : Low impact trawl doors

"Jumper" is an 18 months national project with private funds. It is a continuation of previously developed low impact trawl doors (part of DEGREE EU project and OPTIPECHE French project). The objective is to improve these doors in order to make them applicable to most fisheries where herding effect of doors is not concerned. Numerical simulation of the door behaviour, tank trials and field trials aboard 12m, 25m and 45 m trawlers are undertaken along the project.

BENTHIS project: Benthic ecosystem fisheries impact study

The BENTHIS project began in October, 2012. This European project aims at understanding better the effects of fishing on the marine ecosystems to minimize them, while making sure of the economic and social viability of possible alternative measures or of improvement of existing techniques. Its approach an approach aims at the compatibility between the financial necessities of the industry, environmental protection and fisheries policy. This multidisciplinary project is planned to last 4 years. It involves biologists, technologists and fisheries economists, in partnership with professionals of the fishery and will allow to study key issues to direct the fishery to more sustainable practices, on the basis of strong knowledge, collected within the framework of an integrated project fishermen-scientists. The Nephrops fishery in the Bay of Biscay will more particularly be studied as French study case. To do it, two professional fishermen practising respectively the Nephrops twin trawling and shellfish traps were requested. For the project, one trawler will use twin trawls and single "double codend" and the second boat will use Nephrops traps. The project aims to assess : (1) the impact of the practice of trawling (2 designs) and Nephrops traps on the structure of the exploited populations, on the animal and vegetable species of the area and more generally on the ecosystems; (2) the impact of phenomena independent from fishing on the ecosystems (strong tides, storms, season, etc.); (3) the impact of the intensity and the distribution of the various activities of fishing on the ecosystem (4) the evolution of the yields of Nephrops traps in an area exclusively and significantly fished with this gear; (5) the rates of secondary captures depending on gear, seasons… (6) the economic viability of these fishing techniques, or potential improvements of techniques or modalities of spatial management of the activity.

CASLANG campaign 2012: Nephrops traps trials

The CASLANG campaign 2012 realized by the oceanographic ship Thalia from 27/07/2012 to 14/08/2012 was motivated by a demand of knowledge, tools and expertise, and support for the collective choices of sustainable development of the Nephrops exploitation. The works realized on traps are relatively recent in the Bay of Biscay: Trials in Cape Breton in 2007, ITIS project in 2009 and limited trials by professionals within the framework of the PRESPO program in 2010–2012 (INTERREG). The conclusions of these projects underline the necessity of optimizing the performances of capture of traps, so that this technique can be economically viable and adopted by the professional fishermen, while remaining eco-respectful (i.e. secondly, the trap technique must be considered on the scale of the fishery, taking into account the activity and the pressure already exercised by the other métiers targeting Nephrops). For that purpose, it is necessary at first to describe and to understand the process of capture, and to identify the key parameters which have an effect on the catches to improve them. One of the objectives of the project CPER – Project Contract State/Region- "Sustainable Fishing", supporting this campaign, is to acquire a better knowledge of the alternative techniques, as Nephrops trapping, and will allow in future the development of software of design and digital simulation for all types of fishing gears.

LANGVIVANTE project: Better selectivity and quality for Nephrops

This project represents the first part of a more global project aiming at improving the quality of Nephrops caught in high-sea fishing for the French and the export markets. The LANGVIVANTE project is carried out by the French company "La Houle", financed by "France Filière Pêche"; Ifremer and IDMer are partners of the project. It will begin on March 2013 till October, 2014. Ifremer is involved in the selectivity part of the project, the objective of which is to improve in a significant way the selectivity of the Nephrops twin trawls with the aim of an optimization of catches (commercial size) and better quality (liveliness, resistance, etc.).

Launching of the national project "SELECFISH": Fish selectivity in the Channel and North Sea

This project aims to continue previous projects to improve fish selectivity in the Channel and in North Sea (Whiting and Cod). This project is managed by the Regional Fisheries Committee; selective devices (combination of square mesh cylinder + grid) will be tested in 2013 after optimizing through flume tank trials and video observation at sea.

Support to the "BARGIP" project: Assessment and management of the Seabass fishery

This integrated project aims to improve the assessment and management of the Seabass fishery. The fishing gear technology unit was appealed to implement a small trawlnet for sampling Seabass juveniles (5 to 30 cm) in estuaries or rivers. Adaptations were necessary to implement the trawlnet, initially planned for the capture of fish sizing a few centimeters. Adaptations are possible to make the trawlnet more filtering and being able to work on relatively high speed. Globally the concept was validated to become one of the technical ways allowing the success of the project.

"SOS Stabilité": A project to study and improve dynamic stability of small fishing vessels

This three-year project focuses on 12 to 25 m long fishing vessels. The objective is to develop numerical models to analyse the dynamic stability in particular hydrodynamic phenomena such as slamming or phenomena associating possible fishing gear obstruction. Second objective is to develop electronic systems to assist the skipper in these particular circumstances. Validation is conducted using tank trials and half scale demonstrator used at sea. Then an important training and communication component will be addressed to fishermen. Partners involved are engineering offices in naval architecture and hydrodynamics. Ifremer brings its skill in fishing gear simulation. SOS-Stabilité will end mid-2013, after a prolongation of 18 months.

Numerical simulation: DynamiT and successor

No further developments were achieved on DynamiT software (simulation of trawl gears). The successor of DynamiT is under development. It will address other types of fishing gears, DynamiT being only dedicated to trawl gears.

Studies in hydrodynamics dedicated to fishing gears

The 3 years HYDROPECHE project has ended in 2012. It aimed at improving knowledge in hydrodynamics around fishing nets. Three PhDs constituted the base of the project. One was dedicated to automatic trawl optimization based on different optimization methods. Another aimed at developing a database of tank experimental results from PID images and POD decompositions to separate the different components of flowfields (particularly turbulent part of the flow). The third student has developed a numerical tool to calculate the flow filed around any king of netting construction, in order to improve the fluid / structure simulation process.

Participation to the conference "Ship of the future" - Nausicaa, Boulogne sur Mer (8 February 2013)

In addition to the presentations and discussions around "what the fishing boat of the future will look at?", this conference gave the opportunity to visit the fishing vessel "Frégate III", alongside the quay with a new thermic/electric engine, which will carry out fish pots trials with Ifremer support during the 2nd half-year 2013, within the framework of the project "FREGATE".

12.5 Iceland

12.5.1 Marine Research Institute

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Codend size selectivity for different trawl designs- gadoids

Selectivity of a regular 135mm codend was measured on two different trawls in the Icelandic fisheries for cod and haddock; (i) a 'standard' demersal trawl and (ii) a modified version with horizontal separation panel and thus two codends. L50 for cod and haddock was 6-7 cm lower for the separation trawl, reduced from 43 to 37 for cod and 41 to 34 for haddock. Selectivity measurements onboard a factory trawler with a regular 135mm codend and a 120mm T90 codend were conducted this year (2013). The trawls used are of typical size for the larger trawler fleet, but significantly larger and somewhat different from those used in previous selectivity experiments. L50 for the regular codend was approximately 31 cm for cod and 34 cm for haddock, where reference lengths for area closures are 55 and 45 cm respectively. Narrowing the codend and/or using T90 meshes raises L50 a little, but these results raise questions regarding the effect of trawl design on codend selectivity. In the case of Iceland, the measured selectivity appears to be out of line with MLS and thus management objectives. This needs further investigation and next selectivity measurements will be focused on the trawl designed in the front of standard 135mm codend. A short survey is planned in September 2013.

Codend size selectivity – Nephrops

Two mesh sizes (90 and 105 mm) and different circumferences of *Nephrops* codends were compared in a survey last year (June 2012). The data were collected to obtain basic information on selectivity in the *Nephrops* trawl fisheries. Not surprisingly, narrower codends and larger meshes result in higher L50's. The selection ranges are relatively high, resulting in problematic selection pattern, i.e. high discard rates for the mesh sizes used (estimated to be approx. 40% by number). Following up those results with writing and further data analysing will be done this year. No survey is planned in near future, but improving selectivity in Nephrops trawls would be of importance for the fisheries to be regarded as "responsible".

Attraction and trapping of cod

The objective of this project is to investigate cost-effective ways to trap cod. This work is based on direct observation of how cod are caught in traditional traps/pots. The project included a considerable work finding usable odour-solution to use for attraction and building of odour releaser and control units. The project changed in the course of time, mainly because of many technical hindrances and problems in releasing the odour, but also because of krill aggregation around the experiment equipment. The occasional use of light and cameras led to a swarm of krill, that the fish (mainly cod and haddock) started to feed on. Due to that fact, an experimental trap was built with only a artificial light as bait. Results were promising and next steps in the project has been planned but not carried out. The projects preliminary results led to two spinoff pilot projects; "Grazing cod on krill (Euphausiids) in pens" and "Biology and utilization of krill in Isafjord-deep."

Harvesting of bivalves – new technology

New project was started in 2012 with the objective to find other methods in harvesting bivalves, than using conventional dredges. The work started with a desk study looking for all available data on new methods. Evidence of new approaches and technology were scarce so experiments were started in order to find the "best" solution to pick up bivalves from the bottom. At the end of 2012 an experimental vehicle was built to use in first trials that will be carried out at the beginning of 2013.

Remote devices (Fish Selector) in front of codend to improve selectivity

A work in collaboration with Star-Oddi, to develop a remotely operated device for improving selectivity is still ongoing. The project is led by the Icelandic firm Star-Oddi with technical assistance from MRI and a commercial fishing company. A new prototype has been made and planned to test on board in research vessel this year and following up with test in commercial ship if going well.

12.6 Ireland

12.6.1 Bord Iascaigh Mhara, Ireland

Contact: Daniel McDonald mcdonald@bim.ie.

Mesh Size Selectivity experiment in Celtic Sea

In September 2012, BIM carried out a mesh size selectivity experiment using hooped covers onboard a 22m demersal stern trawler. The trial was carried out to establish the selectivity parameters of a combination of square mesh panels and codend mesh size. 80 mm codend + 110mm smp, 100 mm codend + 100mm smp and an 80mm codend with a 120 mm smp were tested. These combinations of SMP and codend are those incorporated in the new technical conservation measures regulation (**COMMISSION IMPLEMENTING REGULATION (EU) No 737/2012)** that was introduced in August 2012.

Quad Rigging in the Nephrops Fishery

Towards the end of 2012 a few fishermen had expressed interest in changing their operation from twin-rigging to quad-rigging. Currently around 15 vessels have invested in the gear and have reported increased catches of nephrops, reduced fuel costs and a reduction in discards. In early January 2013 BIM carried out a small trial to establish the efficiencies of the Quad-rig gear compared to the twin-rig set up. It is expected that BIM will carry out additional work in 2013.

Seltra Large Mesh Escape Window in the Irish Sea

A trial of the Seltra large mesh escape window in the Irish Sea Nephrops fishery took place in April 2012. Results in terms of cod release were favourable although only small numbers of cod were caught. The Seltra also showed significant reductions in haddock and whiting catches. Catches of Nephrops with the Seltra were 33% less than those in the standard trawl. The reductions of nephrops were unacceptable to industry and as a result requested that further investigation into the rigging of the gear prior to any further trials being completed. As part of the 2013 work program BIM intend to carry out further trials using the Seltra with the main objective to improve the efficiency of the gear.

Rigid Grid in the Irish Sea Nephrops Fishery

As part of the Cod Recovery plan EC Reg. 1342/2008 under article 11 and article 13 Irish vessels have the option of working Rigid Grids, Incline Separator Panels or the Seltra sorting box. Until 2012 only three vessels had been working the grid and were exempt from days at sea effort regime. By the end of 2012 over twenty vessels are now working the Rigid Grid in the Irish Sea. Fishermen have made it clear that the lack of incentives from the EU have discouraged fishermen from being innovative and adapting to new technical measures.

Environmental Management Systems

During 2012, BIM continued to work closely with industry to further implement the Sea-food Environmental Management Systems (SEMS) developed in previous years, however the emphases has shifted somewhat, to vessels achieving BIM's Responsibly Sourced Standard (RSS) The vessels within the RSS increased from 55 to 80 vessels during 2012. One onshore facility has achieved the onshore element of the RSS and there is interest with other companies in becoming involved. Vessels use an Environmental Management Systems as a tool for the development and maintenance of the Responsible Sourced Standard. BIM will continue to support further development of these programmes and its extension of the RSS to onshore facilities will be a priority for 2013. This will create a link from producer through processor to the consumer for product within RSS.

Waste Management

In 2012 a total of 80,000 kg of monofilament nylon netting was exported to Lithuania and Germany for recycling into pellet form for subsequent moulding into suitable end products. Since this project began in 2005, an approximate total of 330,000 kg of waste nylon has been recycled successfully in Lithuania, Germany, Taiwan and mainland China. BIM continued to conduct research into the viability of recycling polyethylene fishing gear and 8,000 kg of waste material was recycled into granule and powder form. Several end products were achieved using the rotamoulding technique and these included large and small net bins, barrels and containers. There's further potential for reusing recycled PE fishing gear in the marine environment for making usable end-products. Potential products include items such as gear-marker poles, rubbing strips (fenders) for harbours, decking for marinas and measuring boards.

Fuel Efficiency and Environmentally Friendly Gear

There have been positive reports of fuel efficiency and lessening bottom impact when using N-Viro dredges in the Scallop fishery. The N-Viro dredges were trialled in 2 locations. The MFV "Shauna Leon", WD220 operated from Kilmore Quay and worked the grounds off Liverpool Bay. This vessel which is 24.45m oal, 92 GT and 221 KW worked 10 dredges a side. A smaller vessel, the MFV "Samlewette" (9.85m loa, 8.28GT and 53.38KW) operated in Galway Bay on the West coast and worked 3 dredges a side. The results of both trials are broadly similar. Both vessels recorded a significant fuel saving which was probably more than 10%. Catch rates were slightly better than those obtained in the conventional dredge. A significant reduction in the weight of stones and gravel was recorded in both locations. On hard granite seabed the N-Viro dredge did not come fast as regularly as the conventional dredge. The most important disadvantage was that the tines wore with excessive speed. The cost of replacing these and the time spent doing so outweighed the catch and fuel benefits of the experimental dredge.

12.7 Italy

12.7.1 National Research Council, Institute of Marine Sciences (CNR-ISMAR)

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eApulia

The aim of this project is the fuel consumption assessment referred to otter trawl fisheries in the South Adriatic by using a vessel monitoring system (VMS) conceived at CNR-ISMAR Ancona (Italy). The VMS consists of two mass flow sensors, one multichannel recorder and one GPS data logger. Data collected from such VMS will be analysed to assess a baseline in terms of fuel consumption for the local otter trawl fishing fleet, in order to evaluate possible future improvements. The project concerns also the introduction of some modifications in the fishing gears in order to increase energy efficiency of such fishery. At the beginning, fishing gears of the vessels monitored will be equipped with trawl monitoring sensors in order to evaluate effective trawl geometry configuration (horizontal opening, door spread, vertical opening etc.). After that, improvements on the fishing gears will be introduced, starting by changing the otterboards, using floating otterboards instead of on seabed otterboards. Data recorded by fuel and fishing gear monitoring systems will be transferred to a remote server by GPRS, allowing an immediate access to data stored and allowing for an instant analysis of the trawl gear operating conditions. All the instrumentation will be installed onboard three bottom trawlers with different length and power, working in the Puglie Region, in Monopoli and Brindisi harbours.

MAREA – Archimedes

The project was built around two main approaches: the collection of literature information regarding the net technical characteristics in the Mediterranean Sea and the field measurements of nets in cooperation with fishermen, netmakers and control authorities. Gillnets, trammelnets, combined nets, and driftnets are currently among the most important passive nets largely used along the Mediterranean coasts for the catch of a large number of demersal, benthic and pelagic species. The first step of the project was to initiate a small-scale fisheries monitoring network through the collection of the available information on all passive net characteristics. The collection of technical information and the definition of technical details of passive nets can be difficult and this can affect the direct measurement process. Therefore it is essential to define a common approach for the collection of the on field data. Therefore a standardized methodology for the direct measurement of technical properties of passive nets (mesh opening, mesh length, net drop, hanging ratio etc.) was established in order to collect information on technical details of passive net. Information from various literature sources (peer review and grey literature, reports, etc.), relevant to describing the different types of Mediterranean bottom-set-nets (trammel, gillnets, combined bottom-set-nets) and small-sized driftnets (< 2.5 km) were collected and harmonized into a database which can support quantitative analysis and simulations. In this phase a first attempt to identify the technical features which mainly affect the net volume and weight was done. Therefore a small-scale fishery monitoring network was initiated through the collection of the available information on all passive net characteristics. At least, this inventory included: technical features of each gear (such as length, height, number of meshes in height, mesh opening, type of floats, etc.), base harbour, target species, fishing areas, and fishing time. In order to collect and classify information on the technology, description and use of the passive net fishing gears in the Mediterranean various sources of information have been identified. Those are primarily scientific papers published in relevant journals. This task was assigned to one partner only so that to avoid overlapping efforts since these sources are common. Secondary sources are the local conferences and RTD project reports which usually are accessible only by the partner Institution in the same country. The review showed that the technical features of passive nets (mesh opening, net drop, netting twine, hanging ratio etc.) mainly depend on the target species. Furthermore the netting properties vary in the different harbours and regions according to local traditions while the fishing effort in terms of net length seems to be correlated with the boat dimensions. The main outcome of this review was to support the European Commission with updated information on the passive net characteristics (mesh opening, twine thickness, net length, net drop, hanging ratio etc.) in order to provide fisheries managers with a complete picture of Mediterranean situation. All this information can represent a useful tool for fisheries managers for the adoption of reasonable measures on the basis of the real situation.

MAREA – myGears

The goal of the project is to collect information on the characteristics of trawlnets used in different Mediterranean fisheries, with a view to possibly establish maximum dimensions and adequate rigging for trawl fishing gears. All these elements will contribute to improve the selectivity, to limit the fishing effort and to minimize the environmental impact of fishing gears. Such information can be useful also to evaluate the potential harvesting pattern of different gears in terms of explored area during fishing operations and thus contributing to underpin specific management measures of fishing capacity. The work is organized in four different workpackages:

- Workpackage 1. Project management and scientific coordination;
- Workpackage 2. Critical review of literature data on gear- and vessel-metrics;
- Workpackage 3. Collection of new data;
- Workpackage 4. Data analysis and modelling.

The study is currently carried out on the basis of the information collected and/or measured in relevant Mediterranean fishing fleets with the collaboration both of the fishing sectors and of the control/inspection bodies. Information are also independently collected through the fishing-nets makers, door manufacturers and, when possible, fishermen. Literature information as well as results from research projects and studies, funded either with national or/and EU support, are used in view of establishing synergies among different scientific domains while avoiding duplications. All data collected are organized in a database that is also able to predict main fishing gear characteristics. Also the literature reviewed as well as the information collected through direct measurements is collected into a devoted database. Empirical relationships among different parts of the fishing trawl gears, including different type of likely attachments, as well as between some of these parts and the otterboard size and the engine power of the vessel are currently under evaluation. Multiple regression modelling, traditionally used in fishing gear engineering analysis will be applied to statistically analyse the relationships among different parts of the fishing gears / otterboard dimension / engine power / and vessel metrics.

Maremed

Among new measures scheduled by the legislative packet published in 2011 (EU COM (2009) 163 final. Green Paper "Reform of the Common Fisheries Policy"), the European Commission included the mandatory introduction of a system of Transferable Fishing Concessions (TFC) specifically aimed at reducing fleet overcapacity and increasing economic viability of the fisheries sector. Transferable Fishing Concessions (TFC) can be defined as a form of rights-based fisheries management that entitle the holder to a specific proportion of its Member State's annual fishing quota or allowable fishing effort. The reformed CFP will therefore include the possibility to adopt a TFC system for fisheries management on a facultative basis at each Member State's discretion. Indeed, given the diversity of fisheries in Europe, Member States should be allowed to choose the management system which is most appropriate to the specific characteristics and requirements of the regional fisheries, based on a set of transparent criteria for economically viable and environmentally and socially sustainable practices. Stemming from these premises and in the framework of the EU Project MAREMED, Marche Region (Italy) as the coordinator of the fisheries theme has developed a pilot action on the applicability of Transferable Fishing Concessions (TFC) in the Mediterranean. The pilot action was carried out in collaboration with other project partners (France: Conference of Peripheral Maritime Regions and Mediterranean Intercommission CRPM-CIM, PACA Region, Corsica Region; Spain: Valencia Region; Italy: Liguria Region, Toscana Region) and academic experts on fisheries (Italy: Fano Marine Biology Laboratory of the University of Bologna, CNR-ISMAR of Ancona; Corsica: STARESO-Station de Recherches Sous-marines et Oceanographiques). The study included an introductory analysis of the legal framework, background information and state-of-the-art at the European level, and an evaluation of the appropriateness, transferability and modes of applicability of a fisheries management model based on a TFC system in the Mediterranean area, which is characterized by multispecific, multigear and small-scale fisheries. This Recommendation Paper provides an overview of the results and conclusions of the pilot action; the complete outcomes of the study including the questionnaires filled in by each project partner are presented in the Final Report, which is available on demand.

Force

FORCE "Fishing and aquaculture-Oriented Research Capacity in Egypt" project is designed to enhance the capacity of the Egyptian National Institute of Oceanography and Fisheries, NIOF to carry out research activities aimed at supporting the implementation of sound and science-based policies for the sustainable development of fishery and aquaculture in Egypt, as well as in the whole Mediterranean North African region. FORCE will enable NIOF to fill the Scientific and Technological gap, which, at present, is one of the main factors that hamper the further sustainable management of fishery and aquaculture. The overall FORCE scientific objectives are to identify potential for more efficient cooperation between EU research institutions and NIOF focused on fishery and aquaculture as means of development of S&T and increasing sustainable yields; to support NIOF in developing a "tool-box" for environmental impact assessment of aquaculture activities; to disseminate the best practices and to raise awareness among scientists, fishery inspectors and policy-makers. In support of reaching competent sustainable management of fisheries, FORCE will promote the principles and objectives outlined in Horizon 2020 frameworks and EU Marine Strategies. FORCE will enhance the participation of Egypt in the FP7 by giving to NIOF the opportunity to coordinate a FP7 project.

Benthis

BENTHIS (Benthic ecosystem fisheries Impact Study) is a five years project, aiming at integrating the role of marine benthic ecosystems in fisheries management. The European Union has funded the Benthis project to provide the urgently needed knowledge to support an integrated approach to the management of human activities in the marine environment, in particular fishing. Main objectives of the project are:

- the assessment of different marine benthic ecosystems status;
- the development of tools to assess effects of bottom trawling on the structure and functioning of EU benthic ecosystems;
- development and testing, in close collaboration with fishing industries, of innovative technologies that reduce the impact of trawl fisheries on the benthic ecosystem;
- development of sustainable management plan in order to reduce the impact of fishing and quantify its ecological and socio-economic consequences, together with the fishing industry and other stakeholders on a regional scale.

Project activities are organized in many case studies (Baltic sea, North sea, Western waters, Mediterranean sea, Black sea), in close collaboration with industry and stakeholders through regional meetings and other events.

Stock Assessment of the striped venus (Chamelea gallina) along Western Adriatic coast

Chamelea gallina (Linnaeus, 1758) is an infaunal clam of the Veneridae family (Bivalvia: Lamellibranchiata: Veneridae), locally known as 'vongola' or 'lupino'. It lives buried within fine well-sorted sands (0 – 12 m depth) where it is so abundant and dominant as to constitute a 'facies à C. gallina'. Annual surveys aimed at analysing and quantifying the Chamelea gallina population in the Maritime Districts of Ancona and San Benedetto del Tronto (Italy) were carried out in 2012 by ISMAR – CNR Ancona as part of stock assessment programme of the whole western Adriatic stock with the aim of providing scientific data for management. Furthermore, a selectivity study has been provided in order to evaluate the selectivity rate of actual hydraulic dredges operating in the Adriatic. A selectivity time saving protocol has been assessed and the size measurements have been carried out using photo analysis which allows an automatic and fast size measurement. Results achieved during 2012 will be compared with those will be obtained during 2013.

EcoFishMan

EcoFishMan is a three years multidisciplinary project, involving scientists and stakeholders in activities relating to biology, stock assessment, technology, economy, sociology and legal aspects of fisheries management. The new system will be based on responsiveness, flexibility, stakeholders' responsibility and communication. Fishermen will provide scientists and authorities with more data than before, using already available instruments such as electronic logbooks. This will allow for rapid response to changes in the environment and increased communication between stakeholders. The burden of proof that the fisheries are ecologically sustainable will be shifted towards the fishermen. With more data exchange, a more focused management of the value chain of fish will be possible and thereby the economic and social outcome of the fisheries is improved. During 2012 the Second Annual Meeting and stakeholder meeting were held at CNR-ISMAR in Ancona.

ICEEF 2012

This project is part of the work programme for action FISHREG. JRC has already developed a pilot website on energy efficiency in fisheries that is available online at https://energyefficiency-fisheries.jrc.ec.europa.eu/. The site is accessible directly through the Europa website of DG MARE for fisheries. The pilot website includes reference documents and studies related to energy savings in fisheries, general information on research and funding opportunities and links to relevant EU projects, EU legislation and events, among others. The information collection is organized in many topics. Each topic reports the state-of-the-art as well as innovations which allow to achieve a sensible fuel saving. The website reports also information about the most important event related to fisheries and energy saving thus representing an interesting opportunity to spread and collect information on energy efficiency for fisheries. The most important result for this website is to become an hub of information to connect scientists, stakeholders and fishermen all together.

BYCATCH V

The project aims at evaluating the bycatch of protected species in pelagic trawl. The second goal of the project was to find solutions to avoid the bycatch of protected species. Pelagic trawlers in the Adriatic Sea only target small pelagic species (Anchovy and Sardine). CNR-ISMAR carried out several observations onboard finalized at monitoring the catch and the eventual bycatch. In order to reduce the bycatch in pelagic trawl a modified TED (*Turtle Excluder Device*) was developed and adapted to a single boat pelagic trawl. The preliminary results are encouraging. Next step will be to test the TED in a pair trawl which is the main activity in the Adriatic Sea.

MARTE+

The project provides for the establishment of a Scientific-Technical Working Group, composed of persons representing the four regions of the border area (Corsica, Liguria, Tuscany and Sardinia), with the following duties:

- analysis of fishing systems in use nell'areale border to assess the positive and critical;
- setup of specific experiments of systems/gears innovative sustainable and take into account the requirements and regulations regarding the needs of the regions involved in terms of traditional fishing activities of fishing communities, socio-cultural and environmental.

In particular, this project claims to proceed with testing of nets for a catch of some species of commercial interest, including the testing of technical equipment available to enhance the selectivity, used mainly in the small coastal fishing. During 2012 and 2013 many trials at sea were conducted for tests with new fishing gears in order to compare their traditional fishing gears with new pots and one experimental surrounding/purse-seine net. Data analysis, showed some differences in the catch species, mainly due to a different operating condition of the pots and the experimental net. Moreover fishermen’s approach to new fishing gear is complicate and it requires time. So that further experimental is needed to better define a comparison within past and experimental gears.

12.8 Japan

12.8.1 Tokyo University of Marine Science and Technology

Contact: Takafumi Arimoto.

Swimming performance of fish

Exercise effect with the forced swimming trials in differed temperatures has been examined in the swimming channel with ECG/EMG monitoring for understanding the endurance time according to the swimming speed, and for estimating the maximum swimming speed through the analysis of stride length and muscle contraction time, on jack mackerel and bluefin tuna.

Visual physiology of fish

Growth change of visual response on bluefin tuna has been examined with the microscopic study of retina structure, for understanding the visual acuity, visual axis and dark/light adaptation process.

U/W video monitoring of trawl capture process

Separating performance of the trouser trawl was monitored by U/W video recorder for examining the codend mesh selectivity. The swimming performance of fish inside the net was also monitored and compared with the swimming channel study.

Technology transfer of Japanese-type set-net in Southeast Asia

The impact of recently introduced set-net in Thailand has been examined with the long -term catch data, through the analysis of mean trophic level on catch sustainability, and the fuel consumption in comparison with other small-scale coastal fishing gears such as gillnet, crab trap and cuttlefish jigging. The accumulation performance of trap chamber was also analysed with the catch data of differed hauling intervals.

Workshop Proceedings on Behavioural study in fish and its implication for stock management

Contact: T. Arimoto, A. Munakata, M. Kobayashi, A. Munakata and M. Kobayashi, H. Yambe, M. Koido, N. Yamamoto, R. Masuda, T. Sunobe, Y. Kobayashi, T. Yoritsune, Y. Sakakura, A. Hagiwara.

Control mechanisms of fish behaviour: 1) Roles of hormones in migratory and spawning behaviours in salmonids; 2) Roles of pheromones in reproductive behaviours; 3) Neural mechanisms underlying fish behaviour and motivation; 4) Sex change and behaviour: ecological aspects; 5) Sex change and behaviour: physiological aspects; 6) Study of reproductive behaviour for conservation of fish.

Fish behaviour and its application for stock managements: 7) Seedling production and fish behaviour; 8) Stock enhancement and fish behaviour; 9) Understanding of capture process for behaviour dynamics.

12.8.2 Nagasaki University

Contact: Yoshiki Matsushita.

Optimizing the lighting system for squid jigging fishery

The lighting system consisting of surface metal halide lamps (MH) and Light Emitting Diodes (LED) for coastal squid jigging boats (19 GT class) has been studied. We have helped building 3 new jigging boats by utilizing our results from past studies. We have also focused on the attraction of squid prey during lighting. To understand the effect of the prey in squid attraction, surveys on prey abundance and stomach contents of squid have been conducted in the field.

Development of a low-drag gear for fuel saving in offshore pair trawl fishery

A low-drag and high profile trawlnet partially using Ultra-high-molecular-weight polyethylene (Dyneema) is designed and tested in the pair trawl fishery in the East China Sea. The prototype net reduced fuel consumption to 98% of a conventional net while a net height was 0.5 m increased. We however confirmed the net height is not important for maintaining catch level. The improved low-drag net that is same proportion of conventional net will be tested this year.

12.9 Netherlands

12.9.1 IMARES/ILVO

Project: ICES research on pulse trawling

IMARES and ILVO carried out a follow-up project with representatives from the fishing industry, pulse trawl producers, and the Dutch Ministry to address problems concerning control and enforcement in shrimp and flatfish pulse trawling developments. Participation from control agencies was strengthened. A new procedure is currently under development. In May 2011 comparative fishing trials were undertaken of two pulse trawl boats (system PulseWing by HFK Engineering and system pulse trawl by Verburg-DELMECO) and a conventional beam trawler fishing nearby. The results were analysed thoroughly and a publication submitted in Fisheries Research titled: van Marlen, B., Wiegerinck, J.A.M., van Os-Koomen, E., van Barneveld, E., 2013. Catch comparison of pulse trawls and a tickler chain beam trawl. IMARES made reference field strength measurements on-board two representative pulse trawlers in November 2011 with gears laid on the bottom. The data were used in the analysis of this catch comparison. Additional reference measures on field strength of pulse trawls *in situ* are planned in 2013. SGELECTRA met in Lorient in April 2012 and will continue its work over 2013. Reports are on the ICES website (www.ices.dk). Contact: Bob van Marlen (bob.vanmarlen@wur.nl), Dick de Haan (dick.dehaan@wur.nl).

Project: Pulse trawling monitoring program

IMARES commenced a pulse trawling monitoring programme in December 2011. The objective of this programme is to get more insight in the catch composition of the pulse trawling fleet, which aims at catching flatfish. The project exists of two programmes; an observer programme and a self-sampling programme. In the observer programme, ten observer trips have been carried out by IMARES and ILVO in 2012. The observers followed the standard discard protocol, which is also used for trips for the EU Data Collection Framework. In the self-sampling programme, 25 vessels have collected data on their catch according to a standard protocol during the period December 2011-March 2013. Analysis of the collected data will be carried out in April-May 2013. Contact: Mascha Rasenberg (mascha.rasenberg@wur.nl)

Project: Shrimp Pulse Trawl

The Shrimp Pulse Trawl project was completed with testing the Belgian "HOVERCRAN" (low impact shrimp pulse trawl) on three Dutch vessels. ILVO and Marelec from Belgium are involved. A report of ILVO came out under reference: Verschueren, B., Vanelslander, B., Polet, H., 2012. "Verduurzaming van de Garnalenvisserij met de Garnalenpuls: eindrapport." ILVO MEDEDELING nr 116, oktober 2012, ISSN 1784-3197., pp. 102. Contact: Bob van Marlen (bob.vanmarlen@wur.nl).

Project: VIP Pulse cable

This project was finished in 2012, but the cable producer De Regt was taken instead. First new cable prototypes were developed and tested at sea. A fairing on the cable proved to reduce its drag. Contact: Bob van Marlen (bob.vanmarlen@wur.nl).

Project: VIP Skipper Network SumWing South

In the SumWing project constructional improvements are designed and tested to reduce structural damage. Some skippers changed to the integrated PulseWing system, in which SumWing and pulse trawling are combined. A problem remains that the lower front side of the wing and the runner show considerable abrasion due to bottom contact. Contact: Bob van Marlen (bob.vanmarlen@wur.nl).

Project: VIP Skipper Network Discards South

A number of beam trawler skippers were interviewed to retrieve their knowledge and experience in reducing discards. IMARES did a short study on the effect on storing hatched sole in fish survival tanks (0.6x0.4x0.12m) both in the lab (control groups) as on FRV "Tridens" in December 2012. Groups of 50-55 individuals were used, with 5 fish per tank. No single fish died in all three groups. A survival experiment with hatched sole (< MLS; as control group) and undersized sole from catches (test group) was carried out in April 2013 from a commercial pulse trawler. Six underwater cages were filled with some 15 fish each and survival monitored. Results are still to be analysed. Contact: Bob van Marlen (bob.vanmarlen@wur.nl).

Project: VIP Skipper Network Net Innovation South

The purpose is to address the problem of discarding by exchanging information on fishing gear and practices. A new square net was tested on a commercial vessel using a SumWing with a higher runner to avoid abrasion. The gear showed unstable behaviour, which was not the case with a conventional round net. Contact: Bob van Marlen (bob.vanmarlen@wur.nl).

Project: VIP T-Line

The T-Line concept is a trawl using pins instead of chains to chase fish out of the seabed. A first trial was done in December 2011 with T-Lines integrated in a SumWing, but the pins had a tendency to break off and catches of particularly sole were not satisfactory. A new version was tested in 2012 (Figure 16). A simulation was made in DynamiT™ on the net with two codends (Figure 17). The SumWing effect was simulated with a weight in front of the wing. ILVO made underwater observations of the gear in January and July 2012 (Figure 18). Further trials are scheduled but depend on the fishery. Contact: Bob van Marlen (bob.vanmarlen@wur.nl).

Figure 16. T-Line elements on a SumWing (left) and detailed (right).

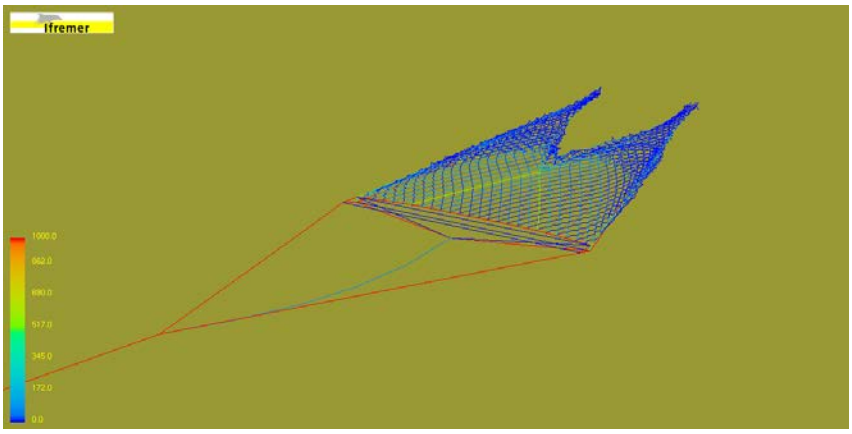

Figure 17. DynamiT simulation of T-Line net.

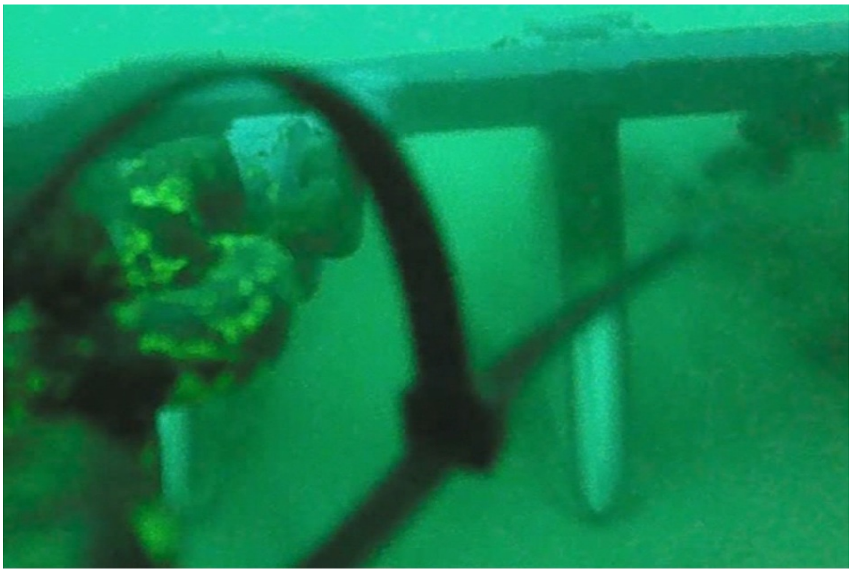

Figure 18. Underwater observation of T-Line element.

Project: VIP HydroRig

This project was rounded off with a final report in 2011. A follow-up project will start running in 2013 with further underwater observations on a new model HydroRig. Contact: Bob van Marlen (bob.vanmarlen@wur.nl).

Project: VIP PALSED

The prototype stunner in which fish can be fed by hand was tested on a commercial fishing vessel in 2012. It is possible to stun fish into consciousness prior to gutting. Further optimization trials are considered. Contact: Bob van Marlen (bob.vanmarlen@wur.nl), Hans van de Vis (hans.vandevis@wur.nl).

Project: VIP VDTN Bycatch Reduction by Technical Means

A series of trials on a horizontal separator panel and an escape window in the top sheet were done on FRV "Tridens", with skippers of the two participating commercial boats. This work is also done in cooperation with ILVO. Most fish seem to end up in the lower codend. Further trials on both vessels will be done in 2013. Contact: Bob van Marlen (bob.vanmarlen@wur.nl).

Project: Fishery Study Groups Flyshoot fisheries

The project is still running and ways are sought to do real-time underwater observations of fly shoot gear. Contact: Frans Veenstra (frans.veenstra@wur.nl).

12.10 Norway

Improved purse-seine technology for lenient slipping of pelagic fish to avoid mortality

Work on lenient slipping technology for pelagic fish species like mackerel, herring and capelin has continued in 2012, with modification of the end of the purse-seine ("bunt") to give a well-defined escape opening. Properly rigged with deck handling winches, the purse-seiners will be able to create a 70 to 90 square meters semicircle escape opening within less than half a minute. The capacity of such an escape or release hole is expected to be several tens of tons per minute. In the second half of 2013, the concept will be recommended introduced as a permanent installed device in all purse-seines to secure lenient slipping in order to prevent mortality of pelagic fish during this process. Contacts: Aud Vold (aud.vold@imr.no), Bjørnar Isaksen (bjoernar.isaksen@imr.no).

Observation and sampling techniques for pelagic species caught by purse-seine

Work on observation techniques for purse-seine has continued in 2012, with special emphasize on housings for video cameras that are able to withstand rough handling during shooting and retrieving of purse-seines. Rubber housings seem to protect video cameras in a reasonable manner, and are thus suitable for use in purse-seines. However, as there is no heavy load on the netting in a purse-seine like it is in a trawl, it turns out to be very difficult to mount a camera in a way that maintains directional stability. The camera will point more or less randomly in a direction given by the net wall in that particular shot, and that particular stage of pursing. The shape of the purse-seine in two subsequent shots is rarely the same, and any attempt of adjustment of the camera is therefore futile. Observation techniques for purse-seine will therefore have to be independent of the net walls and not attached to the gear itself. During 2012 a device for sampling and identification of the catches in a purse-seine has been developed. A small sampling trawl is shot or deployed 30 to 50 meters from the purse-seiner and into the closed purse-seine well before crowding of fish occur. The sampling trawl is opened by kites on the headline and on both side panels, while the groundrope is equipped with leadline. Towed with a speed of about two knots, the sampling trawl has an opening of 1.5 by 1.5 meter. The sampling trawl is deployed from the purse-seiner by a modified airpowered line thrower operating at a pressure of 12 bars. During two cruises, one in 2012 and one in 2013, good samples of North Sea herring as well as Norwegian spring-spawning herring have been caught both during night and daytime fishing. The length distribution of herring from the sampling trawl was identical with that from the main catch. Early 2013 the sampling trawl and line thrower were tested also in the Peruvian anchovy fishery. This equipment, that easily caught herring in boreal European waters, faced difficulties in catching a fast swimming species like anchovy. A bigger trawl and a higher towing speed may be the solution to success in temperate and tropical waters like those in Peru.

Contacts: Aud Vold (aud.vold@imr.no), Kurt Hansen (kurt.hansen@sintef.no), Bjørnar Isaksen (bjoernar.isaksen@imr.no), Michael Breen (michael.breen@imr.no).

Capture Based Aquaculture for cod – a fisherman's companion

On request by, and with financial backup from The Norwegian Fishery and Aquaculture Research Fund, experience from twenty-five years of research and practical testing of live fish technology for cod has been compiled in a easily read manual, mainly dedicated fishermen and fish-farmers who want to start with CBA. The written manual is available in pdf-format on the website www.imr.no and www.nofima.no. During 2013 a web version of the companion will be produced, accompanied with video of above-surface handling of fish, as well as underwater video of fish behaviour during transport from fishing ground, in holding tanks and when stored in large pens. Contact: Kjell Ø. Midling (kjell.midling@nofima.no), Bjørnar Isaksen (bjoernar.isaksen@imr.no).

Fishing and behavioural trials with a large-scale rigid pot in areas unaffected by salmon farms

Based on recent high catches of saithe (*Pollachius virens*) and cod (*Gadus morhua*) in the vicinity of salmon farms in a large-scale rigid pot, The Lofoten pot, (245×245×320 cm, Bagdonas *et al.*, 2012), IMR conducted fishing- and behavioural pot trials targeting cod in areas unaffected by salmon farms in Varanger and Vesterålen (Northern Norway) in autumn 2012. Compared to traditional collapsible two-chamber pots (bottom-set and floated) and a semi-rigid large Newfoundland pot, the Lofoten pot caught most cod, however the catch rates were too low to be a viable commercial alternative. Behavioural trials revealed that 85% of the fish entering The Lofoten pot lower chamber were able to escape while none were seen escaping from the upper chamber, thus calling for more work on entrance design. In areas inhabited by red king crab (*Paralithodes camtschaticus*) promising results on species separation inside the pot, allowing for developing pots that selectively could target cod were obtained. The work will continue in 2013 on fishing grounds and seasons with higher availability of cod. Contact: Odd-Børre Humborstad (oddb@imr.no).

Development of cod pots

Three different pot designs were tested in different areas off the coast of Finnmark (northern Norway) during different seasons. Catches were low for all pot designs in areas and seasons when catches also were low for longlines. The fishing trial carried out in Vesterålen in April gave very high catch rates of cod for the Norwegian two-chamber pot. Two-chamber pots set on the bottom gave higher catch rates than floated pots, and the catch rates for the two-chamber pots were higher than for the Newfoundland pot. The results indicated that squid bait was more efficient than herring bait, which was the bait used by the longliners fishing in the same area. Contact: Svein Løkkeborg (svein.lokkeborg@imr.no).

Survival and catch experiments on wrasse

Wild-caught wrasse are used in aquaculture industry to remove sea lice from salmon. The survival of wrasse in the pens can be influenced by a number of factors such as for example temperature, maturity, physical status and handling. During trials pots and traps were used to catch wrasse (*Ctenolabrus rupestris, Symphodus melops, Labrus bergylta, Centrolabrus exoletus*). The fish were transferred into pens. The results show no correlation between survival and the number of fish in the pens (densities up to 20 fish per m³). No significance differences in survival were found when comparing fishing gears (traps and pots) or setting time. Trials were also conducted using selection devices in traps and pots in order to analyse size selection for the different species. Video recordings from traps and pots have been carried out in order to analyse behavioural differences between species and gear types. Sea trials will continue in 2013. Contact: Anne Christine Utne Palm (annecu@imr.no).

Progress in the development of a Pelagic Survey Trawl – Multpelt 832

The Multpelt 832 pelagic survey trawl designed in cooperation with gear technologist, commercial trawl designers and researchers responsible for pelagic surveys was used and intercalibrated between vessels from Norway, Iceland and Faroese Island conducting a swept-area estimate of the mackerel stock in the North Atlantic. At an ICES working group meeting (WKNAMMM) arranged in Hirtshals the catching performance of the trawl was evaluated and a protocol for use of the trawl for surface fishing was developed. Contact: John Willy Valdemarsen (john.willy.valdemarsen@imr.no).

CRISP

In its second year (started 1 April 2011) the Centre of Research-based Innovation in Sustainable fish capture and Processing technology hosted by the Institute of Marine Research in Bergen, Norway has been working on several projects together with several industry partner, related to development of fishing instrumentation, low impact trawl gears, behaviour studies during trawling and a method to map special distribution of fish in the sea. The activity by the centre and some results is described below. Contact: John Willy Valdemarsen (john.willy.valdemarsen@imr.no).

Acoustic measurements of school biomass and fish size

Kongsberg Maritime, Simrad is collaborating with IMR to develop new fishery sonars which can quantify the size of a school prior to shooting a purse-seine. This includes development and testing of a new scientific data format, and also a calibration methodology tested in 2012 capable of calibrating individual beams in a multibeam system. This project is still in the start-up phase, and work is ongoing with respect to calibration systems for fishery sonars and wideband echosounders. Contact: Egil Ona (egil.ona@imr.no).

Monitoring of fish behaviour and gear performance

IMR continues to cooperate with, Kongsberg Maritime, Simard to develop instruments and improve the communication between the trawl and the vessel using a standard sounder cable for transfer of video and acoustic data to the vessel. The development includes the use of a unit that arrange for communication between several computes in a network, high-frequency sonar, a high frequency echosounder and a monochrome camera with artificial light sources. This system has been tested during four cruises, two with a commercial trawler and two with RV "G.O.Sars". The simultaneous transfer of data though a standard net sounder cable works well, with video signals of excellent quality. Contact: Arill Engås (Arill.Engaas@imr.no).

DeepVision Technology

The DeepVision in-trawl camera system, which identifies and measures fish passing inside a trawl, was further developed in 2012. A new subsea unit integrating the cameras, PC, and communication components into a single 2000 m rated cylinder was used successfully on four cruises between May and October. A modified design of the DeepVision unit was designed and tested during a research cruise with RV "G.O. Sars" in April 2013. The new arrangement for the DeepVision system proved to be much more robust and resistant to coming out of calibration than the system used in 2011. The frame rate was doubled to five images per second and lighting and background contrast were improved, resulting in much clearer images and improved ability to identify and measure passing fish. While integrating species and size measurements from the DeepVision system with an active sorting system remains an eventual goal, development in 2012 focused on improving image quality; image processing software (including automation of length measurements); and data storage and transfer. Testing of the modified version of the Deep Vision unit during the April cruise with "G.O. Sars" was successful. Contact: Shale Rosen (shale.rosen@imr.no).

Catch regulation in trawls

Three different systems have been developed and tested to limit catch sizes in demersal trawling within the CRISP project. Two of the systems are "passive". One with a rubber mat covering an escape opening in the upper panel in front of a fish lock mounted from the top panel back toward the bottom panel. The fish lock lets fish enter the codend but prevents them from swimming back forward. As the codend fills up with fish the water pressure in front of the accumulated fish will lift the rubber mat and let fish that have not yet entered the codend swim out through the escape opening. The other passive system consists of a section with brick meshes (rectangular meshes) and a fish lock in front of the codend. When the codend is filled up a catch sensor is activated and then the skipper conducts a procedure of increased speed followed by sudden reduced speed. During the latter operation the brick meshes will expand, letting the fish escape. The passive systems have been tested in a trawl both with and without a grid section. The other system is "active", with an acoustic mechanism that controls the opening and closing of a motorized gate, blocking the entrance to the codend and opening an escape opening that fish can swim out of the trawl. Video observations revealed that all three systems can limit the catch sizes in demersal trawling. Fish were observed moving toward the codend and calmly swimming out through the escape opening of the passive systems when codend was filled up. All three systems released fish at trawling depth, which will ensure a high survival rate. The passive systems will be further developed. The active system needs development to make it more user-friendly. Integrating the control function of the gate with the Simrad camera and communications system (FX80) is considered to solve different problems. Such problems include; clean catch mitigating measures, releasing unwanted species and length groups of fish, as well as preventing damage to the netting in the sorting section. Contact: Arill Engås (Arill.Engaas@imr.no).

Low impact trawling

Development of trawl doors where both horizontal and vertical forces act on the trawl doors so that it can be adjusted while fishing is a priority area for CRISP. An activity has included development of motorized opening and closing of hatches in the trawl doors through communication via an acoustic link between the vessel and the trawl doors. Testing of this system has been conducted during three sea trials, one experiment with a 2 m^2 trawl door, and two with the research vessel "G.O. Sars" using 9 m^2 pelagic trawl doors. During the latest test in April 2013 the upper hatches in both doors were equipped with motors that could be started and stopped via an acoustic link. The low impact trawling concept also includes the development of a semi-pelagic trawl technique where the trawl doors are positioned off bottom and a trawl gear with less bottom contact than a traditional rock-hopper groundgear. The trawl is also rigged for pull in the netsounder cable resulting in lift of the trawl with a reduced number of floats on the headrope. The acoustic communication system cNODE was efficient as a tool to regulate opening and closing of the hatched in the trawl doors as tested during the latest "G.O. Sars" cruise in April 2013. Off- bottom rigging of the trawl door resulted in comparable catch rates of cod compared to a rigging with the trawl doors on the bottom during comparative fishing trials onboard the trawler F/T "Ramoen". Contact: John Willy Valdemarsen (john.willy.valdemarsen@imr.no).

Trawl survey methodology

Annual ecosystem surveys are carried out in the Barents Sea. These surveys aim to monitor the status and spatial distribution of ecosystem components and to study the population dynamics in the region in order to provide management advice. However, the current techniques do not provide sufficiently fine-scale spatial data to study population dynamics such as the key biotic and abiotic drivers of cohort survival. One component of the survey is mapping the upper pelagic zone using a standard sampling trawl towed with the headline at 0, 20 and 40 m, over a single 0.5 nm tow. All catch becomes mixed in a single codend, and information on spatial distribution and species overlap within the hauls is lost. DeepVision stereo camera equipment was tested in the aft part of the sampling trawl during August 2012. This equipment captures a continuous record of all organisms passing through the extension of the trawl. Individuals ranging from macro-plankton including krill, amphipods and jellyfish to 0-group and adult fish could be identified and measured in the images. Fine-scale patchiness and species overlap was documented both vertically and horizontally along the cruise track. Contact: Arill Engås (Arill.Engaas@imr.no).

Species-selectivity trawl for demersal gadoid fisheries

Experiments were carried out in the Barents Sea during two cruises in 2012 to test a species selective demersal trawl for separating cod and haddock. A sorting system was installed in a commercial trawl, incorporating a horizontal panel dividing the trawl's body and extension sections into upper and lower compartments, leading aft to vertically oriented trouser codends. Two types of horizontal dividing panels were tested, a square mesh panel (150 mm bar length) and a brick mesh panel (150 by 500 mm bar length). Cod were mainly caught in the lower codend, while haddock were mainly caught in the upper codend. For both species a large haul-to-haul variation in distribution between the two codends was found. Similar results were obtained with the two types of panels. Contact: Arill Engås (Arill.Engaas@imr.no).

Development of Trawl simulation software (CATS 2)

The objective of this project is to update the simulation software CATS which was made in the mid 90ties to a new version where more fishing gears can be analysed. The updated software can be used for analysis of trawls and seines with diamond, hexagonal meshes and or nets incorporating square mesh sections. The software can handle a number of different operations like trawling in either single or multi trawl configurations. The updated software will also be able to handle the seining process of a Danish Seine. Contact: Kurt Hansen (kurt.hansen@sintef.no).

Sorting grid selectivity at high catch rates

Sorting grid selectivity in bottom trawling at very high catch rates (>0.5 ton per minute) has shown a series of problems. 1) The sorting grids get saturated because of its relative small surface area in relation to the amount of fish meeting the grid simultaneously. As a consequence, the selection process is far from optimal. 2) Sorting grid (especially the flexi-grid section) appeared to strongly attenuate the water flow inside the grid section. As a consequence of this water flow attenuation large quantities of fish are able to swim in front and behind the sorting grid, not falling back to the codend until the start of the haul back operation. Later experiments has shown that the water flow inside the Flexi grid section is attenuated by 80%, and that is mainly originated by the presence of two small-meshed guiding panels (60 mm nominal mesh size). In addition to this, the accumulation of fish in front and behind the grid provokes that the catch sensors do not give the real picture of the total catch. 3) When the catch sensor is activated and indicated a certain amount of fish in the codend, the facts is that large quantities of fish has not fallen back to the codend. In recent years, this has led to unwanted big catches been taken by the fleet. Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Development of catch control device for trawls

This project is aimed at developing prototypes of catch control devices that could help controlling the size of the catch and that gently release the excess of fish at the same fishing depth. So long three prototypes have been developed and tested at sea giving encouraging good results. The main challenge that has been identified is related to the use of grid sections that reduce water flow in the trawl and causes that fish does not falls back to the codend. Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Development of multirig semi-pelagic trawling

This project is aimed at increasing energy efficiency in the Northern shrimp fishery and the northeast Arctic cod fishery. So long this project has focused on: i) developing a gear control system mainly via enhanced winch control and vessel manoeuvring control; ii) developing a new self-spreading groundgears that reduces the escape of fish under the gear; iii) quantifying the differences in catchability and energy consumption between bottom trawling and semi-pelagic trawling. Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Random pairing as an approach to measure selectivity in commercial-like trawl fisheries

Trawls are one of the most widely used fishing gears around the world because of their flexibility and capacity to adapt to almost any fishery, type of seabed and weather conditions. The limitations and challenges often encountered by the scientists when working at sea have had as consequence the development of different sampling methods. In fisheries where the covered codend method cannot be used and the paired gear method cannot be applied the so called alternate haul method is often used. The study of selectivity in big pelagic trawlers is among the most challenging within trawl selectivity studies. The fact that the catches in these types of vessels are often big (>30 tons) have implications on the use of the covered codend method and the paired gear method. Converting the gear from a control to a test gear (necessary to apply the alternate haul method) and the steaming required carrying out the control and the test hauls parallel can become time consuming processes that commercial vessels cannot afford. Consequently, a bulk of control hauls are often first collected followed by a bulk of test hauls, which later need to be paired. In trials carried out in this manner the amount of collected control hauls do not always match the amount of collected test hauls (unbalanced hauls) and in this situation there is a tendency for the hauls that cannot be paired to be discarded. Practical limitations often lead to analytical challenges and the data collected in this way often need to be analysed as pooled hauls (all control hauls and test hauls are pooled separately and then analysed as a single haul) or as individual hauls where the first collected control is "artificially" paired with the first test haul, the second control is again "artificially" paired with the second test, etc. Both of these procedures have analytical deficiencies mainly linked to the estimation of the confidence limits of the mean selectivity estimate values. This investigation is a selectivity study where the performance of a sorting grid system, a T90 codend and a codend with EW is compared using the alternate haul method in the Norwegian pelagic trawl cod fishery. The work proposes a method to cope with some of the challenges of running selectivity studies using the alternate haul method in trawl fisheries in general and pelagic trawl fisheries in particular. The method of random haul pairing presented i) overcomes the problems of having with unbalanced control and test hauls and ii) deals with the challenge of confidence interval underestimation. Contacts: Manu Sistiaga (manu.sistiaga@sintef.no), Bent Herrmann (Bent.herrmann@sintef.no), Eduardo Grimaldo (eduardo.grimaldo@sintef.no).

Size selectivity of redfish (*Sebastes* spp.) in the Northeast Atlantic using grid-based selection systems for trawls

In a collaboration with the University of Tromsø have a study on the size selection of redfish in grid-based selection systems been conducted. This study partly seed from that this subject have been a topic for WGFTFB during the last two years annual meetings. A scientific paper based on the study has been accepted for publication in Aquatic Living Resources (Vol. 26, 2013). Contact: Bent Herrmann (Bent.herrmann@sintef.no).

Danish seine: Computer based design and operation

The main objective of this project is to develop two software tools for Danish seine fishing that ease future transition to the environmentally friendly Danish seine fishing method and that will support development of more optimized gear designs:

- A tool that enables the skipper to simulate the behaviour of the gear with different riggings and different operation procedure.
- A tool that enables the netmaker to create new net designs and evaluate their performance through simulations.

The project will run for three years (2013-2015). The research work will be divided between development of simulation models, development of software tools and verification of tools and models. The research team will be mainly SINTEF Fisheries and Aquaculture (SFH) and the University of Tromsø. But additional international expertise will be provided through an expert workshop. Industry will be involved through workshops. Contact: Bent Herrmann (Bent.herrmann@sintef.no).

The influence of twine thickness, twine number and netting orientation on codend selectivity

In connection With ICES SGTCOD and based on access to vessel time from Thünen-Institute of Baltic Sea Fisheries (Germany) have SINTEF Fisheries and Aquaculture been involved in a study to investigate the influence of twine thickness, twine number and netting orientation on codend selectivity. A scientific paper based on the study has been accepted for publication in Fisheries Research. Contacts: Bent

Herrmann (Bent.herrmann@sintef.no), Daniel Stepputtis (daniel.stepputtis@ti.bund.de).

Modelling towing and haul-back escape patterns during the fishing process: a case study for cod, plaice, and flounder in the demersal Baltic Sea cod fishery

In connection with ICES SGTCOD and based on access to vessel time from Thünen-Institute of Baltic Sea Fisheries (Germany) have SINTEF Fisheries and Aquaculture been involved in a study to investigate the escapement pattern during towing and haul-back of demersal trawling. A scientific paper based on the study has been accepted for publication in ICES Journal of Marine Science. Contacts: Bent Herrmann (Bent.herrmann@sintef.no), Daniel Stepputtis (daniel.stepputtis@ti.bund.de).

New fuel- and catch efficient active fishing gear concepts based on trawl and seine

A project was started in 2009 and running to 2013, with the aim to reduce NOx- and other environmental emissions and impacts from demersal fisheries, by proposing new fuel- and catch efficient active fishing gear concepts based on trawl- and seine technology. The project shall propose new rational fishing strategies and develop new, feasible gear concepts in close cooperation with fishermen and the fishing industry, through workshops, lab tests and numerical simulations, including aspects such as net design, towing resistance and catch efficiency, including among other things a PhD in Operational Analysis. A matrix of potentially interesting combinations of nets, spreading devices and groundgear for bottom trawls, (semi-)pelagic trawls and (Scottish) seines has been established and tested in the Hirtshals flume tank, and some of these will be followed up with full-scale trials. Contact: Svein Helge Gjøsund (Svein.H.Gjosund@sintef.no).

Quality of net caught Greenland halibut in relation to soaktime

Trial fisheries for Greenland halibut (*Reinhardtius hippoglossoides*) was conducted with gillnets during 2010 and 2012, to provide documentation regarding the effect of soaktime on the quality of the catch and the level of discards. The trial fishery was conducted with the net boat "Nordic Prince" west of Husøy in Senja, from the 17th to 30th August 2010, and "Julsund Senior" off the northwest coast (Storegga) from 08 to 22 June 2012. Gillnets with a soaktime of 1 to 4 days were fished alternately during the period. After hauling, the catch quality was evaluated in respect to mortality and damage caused by benthic organisms or fishing gear. As found previously, the major causes of reduction in quality was due to the influence of benthic organisms and net mortality and the effect increased with increasing downtime. With one day's soaktime, approximately 20% of Greenland halibut was defined as discarded. No significant difference in total catch between nets with soaktime of 1, 2, 3 and 4 days were found. The absence of increased catch rates and the absence of a more pronounced reduction in the quality of the catch in nets with downtime from 1 to 4 days, strengthens the assumption that there is a "replacement" of fish in the nets. A first rough estimate of the size of this "waste" is in the range of 10-20% of net catch per day. Contact: Inge Fossen (inge@mfaa.no).

Pelagic bottom trawl

The principle mechanisms in bottom-trawl fishing have remained unchanged since the early 1900's. Higher oil prices and relatively low market prices on fish have motivated the fishing fleet to improve efficiency. In this project, we found that there are significant cost savings to be made by reducing the friction between the fishing equipment and the seabed. This is achieved through the use of pelagic trawl doors instead of the normal bottom-trawl doors. The pelagic trawl doors keep the trawl open sidewise as usual, and are also responsible for the height of the trawl's headrope. Along with a new trawl design and new trawl rigging, this has resulted in significant savings related to the operation and there are indications that catch levels are higher. Tweaks and testing was done on board the "M/S Roaldnes" (34 m) while targeting pollock, haddock and cod during 2010. The project has several partners who aimed to further develop the traditional bottom trawl to a more efficient and environmentally friendly fishing gear. The results related to the use of pelagic doors to pull the bottom trawl have been so successful that one expects that more vessels will adapt the method. Preliminary estimates indicate that the rigging reduced fuel consumption by up to 18% and costs related to gear maintenance were also lower (expected reduction ~ 40%). The figures are based on experience from approximately 1 year of fishing with the new rigging and from records from the company's finance department. The project did also test a new trawl, developed by Vonion P/F. The trawl is the first bottom trawl constructed with a pelagic trawls upper half, meaning it has no own buoyancy. So far the experiences gained are positive and the trawl seems to increase catches compared to the traditional bottom trawl especially at night. It is expected that there is potential for increased catches and further reductions in fuel consumption through further optimization as experience in using the gear increases. A more detailed description of the actual cost changes will allow the adaption of the technology to other vessels. Contact: Inge Fossen (inge@mfaa.no).

Effect of aquaculture activity upon wild marine fish off Nordmøre

As part of the project "Environmental Documentation Nordmøre", this work package describes the impacts of aquaculture activities on whitefish in the region. This is done through contact with fishermen, landing facilities, authorities and organizations. Moreover, fishing activities near fish farms were registered in order to gain an indication on the extent of this. Reduced quality of whitefish doesn't appear to be a significant problem for coastal fishermen in Nordmøre. Reported problems are local in nature, and the extent seems to have declined in recent years. The described pattern is supported by various parties who have good knowledge of the coastal fishery in this area. In Nordmøre there is directed fishery close to aquaculture facilities. Tourist fishermen dominate this, but the results suggest that there are weekly deliveries of fish from commercial fishermen who are fishing close to the aquaculture facilities in the region. This supports the assumption that quality reduction in the wild seems to be a limited problem here. Land seizures and uncertainty related to possible impacts seems to be a more serious challenge for the professional fishermen in the region. Contact: Inge Fossen (inge@mfaa.no).

12.11 Scotland

12.11.1 Marine Scotland – Science, Marine Laboratory, Aberdeen, Scotland

Catch comparison trials with the Faithlie Cod Avoidance Panel (FCAP).

Catch comparison trials were conducted in the North Sea to evaluate the Faithlie Cod Avoidance Panel that has been developed by Willie Hepburn of Faithlie Trawls, Fraserburgh. After modifying the original design by increasing the size of the fish outlet holes the results show a large and significant decrease in the number of the three main whitefish species retained. The reductions by weight of cod, haddock and whiting are 62, 74 and 66% respectively. Due to the fact that there were very few Nephrops caught it is not possible to determine whether the Faithlie Cod Avoidance Panel has any effect on their capture. Contact: r.kynoch@marlab.ac.uk, b.oneill@marlab.ac.uk.

Catch comparison trials with the Scotnet Internal Cod Flap (SICF).

Catch comparison trials were conducted in the North Sea to evaluate the Scotnet Internal Cod Flap developed by Andrew Whyte of Scotnet Trawls, Fraserburgh. The overall reduction in cod by number and weight between the test and control gears were 20% and 36% respectively. The haul to haul reductions in weight were variable and ranged from 7.5% to 84.6%. The reductions by weight of monkfish and haddock are 67.7% and 61.1% respectively. Very few Nephrops were caught during the trials so it is not possible to determine how catches will be affected by the SICF. This gear failed to achieve the 60% reduction by weight of cod required to be classified as a Highly Selective Gear. However, subsequent modifications have been made and the gear is currently being evaluated by three commercial Nephrops vessels. Contact: r.kynoch@marlab.ac.uk.

Trials to develop a whitfish trawl to release cod but retain monkfish and megrim

Selectivity trials of a whitefish trawl with large mesh panels in the side netting were carried out with the aim of releasing cod but retaining megrim and monkfish on fishing grounds north of Shetland. Two designs of gear were tested both of which released about 65 and 45% of cod respectively. Unfortunately both gears also released about 60% of megrim. Due to low catches it is difficult to draw any conclusions for monkfish, but there are indications that for one of the gears there were no differences with the control gear. Contact: k.summerbell@marlab.ac.uk, b.oneill@marlab.ac.uk.

A short-term economic assessment of selective gears

The Scottish Conservation Credits Scheme (SCCS), which was set up in 2008 to support the EU cod recovery plan, uses a range of management measures to reduce the fishing mortality and discarding of cod. It encourages the use of fishing gears that are more selective for cod by rewarding vessels using more selective gears with additional fishing opportunities (i.e. extra days at sea). The gear options available include increasing codend mesh size, fitting a square mesh panel in the extension section, fitting large mesh size belly panels (behind the footrope) and increasing the mesh size of the whole of the forward section (the belly panel and all netting above and forward of it. They are categorized according to how selective they are thought to be for cod and the number of days extra fishing that is offered as an incentive depends on which category they are in. A short-term economic assessment of fishing the large mesh gear options was carried out to help evaluate the attractiveness of the incentives on offer and the likely uptake of the options by the different fleet segments. Contact: b.oneill@marlab.ac.uk.

Further Studies on a 45 mm Flexible Grid in a Scottish Nephrops Trawl Fishery

Catch comparison trials was conducted in the North Sea to examine the effect on cod, monkfish and nephrops retention of fitting a Nephrops trawl with a newly designed flexible grid with 45mm bar spacing plus open bottom gaps of either a) 315mm or b)

200mm. The trials demonstrated that the grid with the open gap of 315mm reduces cod retention by 59% by number and 67% by weight and that the grid with the open gap of 200mm reduces cod retention by 84% by number and 95% by weight. There was no evidence of Nephrops being lost from either grid; however, both grids had significant reductions of haddock, whiting, saithe, monkfish, witch and plaice. Contact: j.drewery@marlab.ac.uk, r.kynoch@marlab.ac.uk.

12.12 Sweden

12.12.1 Swedish University of Agricultural Sciences – Department of Aquatic Resources

Contact: Hans Nilsson (hans.nilsson@slu.se), Johan Lövgren, Sven-Gunnar Lunneryd Sara Königson.

Development of size selectivity in the Swedish grid

This project is a collaboration between gear researcher and local fishermen to include size selectivity in the Swedish grid on the target species *Nephrops norvegicus*. The size selectivity on Nephrops is obtained by a dual grid system with a lower panel with 22mm bar distance and an upper panel with 40 mm bar distance. The later work has been focused on different codend solutions including diamond mesh to remove flatfish and square mesh windows to reduce bycatch of smaller cod´s passing the grid system. During 2013 the project will focus on to include the suggested gear solution into the legislation and technical measure for the Kattegat and Skagerrak area.

Development of size selectivity in the shrimp grid

This project is very much the same as the project "Development of size selectivity in the Swedish grid " and is collaboration between gear researcher and local fishermen. In this project the focus is on size selectivity on the target shrimp species *Pandalus borealis* using a dual grid system.

Lot 1: Collaboration between the scientific community and the fishing sector to minimize discards in the Baltic cod fisheries

This project is a collaboration between scientist and industry from Sweden, Denmark, Germany and Poland and is ordered by the European Commission. The main goal of the project is to minimize the discard of cod using technical and management solutions and analyse the impact on different solutions on economic performance for the fishery and stock assessment. This project will be ended in autumn 2013.

Development of cod pot

The effect of entrance construction variables of pots on the ingress and egress rate of fish was examined by experiments with Atlantic cod in captivity. Video observation of seal attacks of fish trapped in different modifications of "seal safe" cop pots were done close to seal haul outs.

Development of size selectivity in set trap

Studies with video cameras and catch efficiency were done on whitefish (*Coregonus laveratus*) and perch in the Baltic. Both encircling square mesh netting panel and smaller selection panels were tested.

12.13 USA

12.13.1 Massachusetts Division of Marine Fisheries – Conservation Engineering Program

Contact: mike.pol@state.ma.us, david.chosid@state.ma.us, mark.szymanski@state.ma.us.

A Network to Redevelop a Sustainable Redfish (*Sebastes fasciatus*) Trawl Fishery in the Gulf of Maine

This project is a collaboration among netmakers, gear researchers and other scientists, fishermen, processors and regulators to increase exploitation of a fully rebuilt stock of redfish that was once nearly unfishable due to small numbers. The project consists of multiple components including exploratory fishing, codend selectivity, bycatch reduction, marketing, and outreach. Exploratory fishing is completed showing good ability to target fish with codend mesh smaller than legal size (114 mm). Under an exempted fishing scheme, vessels can now target redfish with this smaller mesh. Codend selectivity trials of this mesh size and two large ones using a trouser trawl were conducted in spring 2013; data are under analysis. Collaboration with Pingguo He of SMAST and others.

CEMFIN/GEARNET: Conservation Engineering Marine Fisheries Initiative

This collaborative network has the goal of assisting industry transition to output controls by identifying short-term technology transfer and pilot gear projects, based on existing knowledge and experience that could quickly reduce bycatch and avoid weaker stocks. Thirty projects have been funded. Phase 1 projects are completed or underway; a second phase was solicited and funded with a notable interest in the use of smaller diameter twines, semi-pelagic gear, and other drag reducing/fuel saving modifications. In addition, interest in raised footrope/norsel gillnets continued. This project also supported a very large purchase of new generation gillnet pingers to discourage bycatch of *Phoecena phoecena.* The new pingers have an LED to signal that they are functioning. Field efforts will continue until August 2013. Collaboration with Steve Eayrs of GMRI, Pingguo He of SMAST, and others. www.gearnet.org

A Low-Cost, Underwater Self-Closing Codend to Limit Unwanted Catch

This innovative codend reduces bycatch by automatically closing itself off from the rest of the trawlnet after catching a preset, adjustable, volume. Using low-cost hardware, the filling codend initially caused the release of a line that allows the codend to fall back and to cinch shut while allowing other fish in the net to escape. This project continued with flume tank testing that resulted in a modification to the design so that the expanding codend releases the parachute, and tension on the parachute releases the cinching line for the codend. More fieldwork is planned for summer 2013 to test the new design.

Investigation of Haddock and Flounder Behaviour near Standard and Floating Bridles

In collaboration with Pingguo He, underwater video and catch comparison was used to assess the impact of floating bridles made of Dyneema with standard groundgear on a commercial fishing vessel. Video analysis of behaviour shows little or no contact with the seabed with floating bridles, and a much higher level of disturbance of skates (Rajidae) and other species with traditional groundgear. Effect on targeted haddock catch in paired comparisons was hindered by low catches and vessel breakdown. Current efforts include modelling to correct camera distortion of fish behaviour.

Design and Test of a Squid Trawl with Raised Footrope Rigging and a Grid Device to Reduce Winter Flounder, Scup, and Butterfish Bycatch

A grid was tested in 2011 and 2012 to reduce bycatch in a longfinned squid trawl fishery in coastal waters. Following flume tank testing of a rigid grid with adjustable spacing, a rigid, adjustable grid was tested in to reduce bycatch in a squid trawl fishery in coastal waters. Analysis of squid behaviour shows active escape responses at the grid with mantle orientation important to escape likelihood. Catch analysis indicated unacceptable loss of squid. Further work is planned.

Bayse, S.M., P. He, M. V. Pol and D. M. Chosid. 2013. Quantitative analysis of the behavior of longfin inshore squid (*Doryteuthis pealeii*) in reaction to a species separation grid of an otter trawl. Fisheries Research. http://dx.doi.org/10.1016/j.bbr.2011.03.031

12.13.2 NOAA Fisheries, Northeast Fisheries Science Center (NEFSC), Protected Species Branch, Woods Hole, Massachusetts

Contact: Henry.Milliken@noaa.gov.

More info: http://www.nefsc.noaa.gov/read/protspp/PR_gear_research/

Evaluation of a Topless Bottom Trawl Design with a 160 Foot Headrope for Fish Capture

Building on previous work to reduce sea turtle bycatch while maintaining the targeted catch, the results of this evaluation indicate that the 48 meter (160 foot) headrope, 24 meter (80 foot) hanging line, topless trawl significantly reduced the catch of summer flounder *(Paralichthys dentatus)* and skates (*Leucoraja sp.)* when compared to the traditional trawl. Two vessels carried out the evaluation, and the mean loss of catch by F/V Darana R was 51% for summer flounder and 48% for skates, the dominant bycatch. The mean loss of catch by the F/V Caitlin and Mairead was 74% for summer flounder, and 31% for skates. In general, the addition of floatation appeared to improve the catch retention, but there were an insufficient number of replicate trawls with the increased flotation to evaluate this effect. Flume tank testing is scheduled for May 2013 with the expectation of resolving operational problems with this gear. Further fieldwork is scheduled for the summer and will be determined after the flume tank testing is complete.

Assessment of the Impacts of Gear Modifications in the Monkfish Fishery on Bycatch of Atlantic Sturgeon

The majority of sturgeon *Acipenser oxyrinchus* bycatch mortality in the Northwest Atlantic is attributed to the monkfish sink gillnet fishery. In 2011, we subjected two different tie-down configurations: standard (12 meshes with 122 cm (48 inch) tie-downs) and low profile (six meshes with 61 cm (24 inch) tie-downs) to the same experimental protocol. Bycatch of Atlantic sturgeon and landings of targeted species were both significantly reduced in the low profile tie-down gillnets. During 2012 we compared another low profile net configuration (eight meshes tied-down to 61 cm (24 inch)) which reduced Atlantic sturgeon bycatch with minimal impact on the landings of targeted species. Our findings suggest that the use of tie-downs is important for maintaining adequate catches of target species, and that certain tie-down configurations can reduce Atlantic sturgeon bycatch. Additionally, experimental testing of gear developed by harvesters allows for the identification of gear configurations that both address conservation objectives and are realistic for use in commercial harvest.

Development and Testing of a Tow Time Data Logger to Monitor and Enforce Tow Time Restrictions in Trawl Fisheries

Tow time restrictions have been discussed as a viable alternative to Turtle Excluder Devices (TEDs) in fisheries where TEDs are likely to significantly reduce targeted catch. Tow durations less than an hour are usually expected to result in a negligible number of sea turtle mortalities. The Protected Species Branch of NOAA's Northeast Fisheries Science Center (NEFSC) solicited a contractor to develop and construct a robust, simple, and inexpensive data logger that could be used to enforce tow-time restrictions on commercial bottom-trawl fishing vessels. These loggers, which are attached to the trawlnet or the trawl doors, were tested for their ability to reliably record trawl fishing times and to detect when a tow exceeded a certain time threshold. The testing occurred on eight vessels operating in six fisheries and has shown that the logger holds up to the physical abuses of the salt environment and the shock and vibration of commercial fishing practices. Currently, we are testing the working prototype for extended durations. Because these loggers are also programmable, they may have applications in other fisheries where there is a need to monitor, record, or enforce fishing time.

Other NEFSC-identified future projects:

Seabird bycatch reduction through completing gillnet seabird bycatch estimation analysis (2011–2012)

Seabird bycatch reduction through completing seabird bycatch estimation analysis for gear type(s) other than gillnets (2011–2013)

Turtle bycatch reduction in non-scallop trawl fisheries (2011–2015)

Continuation of the estimation of bycatch of turtles and marine mammals in Northwest Atlantic trawl, gillnet, pot, dredge and longline fisheries (2011–2015)

Finfish bycatch reduction in squid, herring, and Northeast multispecies trawl fisheries (2011-2–15)

Atlantic large whale take reduction in fisheries that entangle whales, through the development of gear modifications and other technologies to reduce takes (2011-2015)

12.13.3 Consortium for Wildlife Bycatch Reduction

Tim Werner, New England Aquarium (twerner@neaq.org), Center for Ocean Engineering, University of New Hampshire, Maine Lobstermen's Association, Duke University Marine Lab, Blue Water Fishermen's Association

The Consortium for Wildlife Bycatch Reduction is a partnership of fishermen, wildlife biologists, and engineers. The Consortium supports collaborative research between scientists and the fishing industry to develop practical fishing techniques that reduce the bycatch of threatened non-target species. Projects supported by the Consortium come under three main categories: (1) Global exchange of bycatch reduction technology; (2) Understanding wildlife interactions in commercial fishing operations; and (3) Research and development of bycatch reduction methods. Some of the Consortium's current projects are described below. Additional details on Consortium projects, including a searchable database of bycatch mitigation techniques, are available at www.bycatch.org.

Endangered Species Research Special: Techniques for reducing by-catch of marine mammals in gillnets

New England Aquarium

Gillnetting is one of the leading fisheries methods worldwide, especially among small-scale and localized fisheries, where the annual catch can exceed that of the industrialized sector. Bycatch in gillnets is a serious threat to many marine mammal species. A theme section of the journal Endangered Species Research features papers evaluating various techniques for reducing marine mammal bycatch in gillnets, including acoustic deterrents, non-acoustic gear deterrents (e.g. modifications to gillnet material), time-area closures and gear switching (e.g. from gillnets to hook and line). The collected papers were presented at the International Marine Mammal – Gillnet Bycatch Mitigation Workshop, held in October of 2011. See: http://www.int-res.com/journals/esr/esr-specials/techniques-for-reducing-bycatch-of-marine-mammals-in-gillnets/ for free access to papers.

Tests of Various Hook Designs (Circle, Offset, Tuna, and J) and Strengths

University of North Carolina at Wilmington, Duke University

Odontocete species that depredate longlines are at risk of becoming hooked and seriously injured or killed in the process. This project seeks to assess the "hook pulling" jaw strength of pilot whales, Risso's dolphins, and false killer whales to provide biological guidance for whale-safe hook trials. Five commercially available and commonly used longline hooks (M-16, M-18, K-16, K-18, and J-9) were tested to measure the forces required to pull the hooks through the soft and hard tissues in the mouths of small toothed whales and to document resulting tissue injuries. The M-16, M-18, and J-9 hooks straightened under maximum forces of 75-200 kg and sliced through the lip tissue, releasing the hook intact. The K-16 and K-19 sustained forces of 150–250 kg then the hooks broke or tore through the lip. The tears created irregular, jagged lacerations and sometimes left shards of hook in the soft tissue. This hook behaviour was consistent across species, suggesting their mechanical behaviour was due to the materials from which the hook was manufactured.

Atlantic Shark Bycatch Reduction

NOVA Southeastern University, Florida Atlantic University, Florida State University, New England Aquarium

Sharks are often caught in large numbers in longline fisheries and although they are usually discarded alive, post-release mortality may be high. Shark bycatch can also have high financial costs to the fisheries due to depredation, hook occupancy, gear loss, and shark handling time. This project, planned for the spring and summer of 2013, examines potential deterrents to reduce rates of shark bycatch on longlines while not impacting target catch species. Fishery-independent longline surveys will be conducted in the Gulf of Mexico to test the efficacy of using electric decoys. The electric devices will also be tested aboard a commercial pelagic longline vessel in the Southeastern US swordfish fishery.

Assessments of Vision to Reduce Right Whale Entanglements

New England Aquarium

The North Atlantic right whale is the most endangered large whale in the North Atlantic, with less than 500 individuals alive today. Population growth is hindered by high levels of human-caused mortalities, including entanglement in fishing gear. This work seeks to determine if the colour or visible features of ropes could provide a visual deterrent, averting entanglements. Previous research determined that right whale photoreceptors best detect underwater background light, and are insensitive to wavelengths greater than 650 nm, or the red region of the visible spectrum. This means that red objects in the water produce high-contrast dark silhouettes against the bright background light. Rope mimics of a variety of colours were created and deployed in Cape Cod Bay, where right whales skim-feed at the surface. An analysis of change of behaviour when presented with the ropes showed that there was a significant difference between interactions with red and orange ropes (n = 7, mean distance = 6.21 m) vs. black and green ropes (n = 8, mean distance = 2.625 m). This suggests that using red or orange rope for fishing gear may improve whales' ability to detect and avoid ropes under some conditions.

12.13.4 University of Massachusetts Dartmouth, School for Marine Science and Technology (SMAST), New Bedford, MA

Groundfish Group [Contact Steve Cadrin, scadrin@umassd.edu]

Discard Mortality Estimates for Winter Flounder Using Reflex Action Mortality Predictors (Adam Barkley)

Estimating the survival rate of winter flounder *Pseudopleuronectes americanus* that are discarded is increasingly important for stock assessment and fishery management because recent regulations increased discarding. A controlled experimental trawl was used to test seven reflex actions from stressed and unstressed winter flounder. The suite of reflexes makes up the Reflex Action Mortality Predictors (RAMP). Tow-time and air exposure were tested to identify their effect on mortality. Mortality was significantly related to reflex impairment, but neither air exposure nor tow-time significantly affected the survivability of winter flounder. Although air exposure did not significantly affect survival, none of the experimental fish exposed to air for 15 minutes or more survived; suggesting that the discard mortality could be reduced by limiting the length of time the fish are on a dry deck. Reflex impairment observations were made aboard commercial trawl and scallop dredge vessels and demonstrated a discard mortality range of 10% to 44%, which is significantly less than the 50% currently assumed for stock assessment and catch monitoring. The reflex impairment-mortality relationship will enable more representative estimation of discard mortality aboard commercial fishing vessels for various gear types and all seasons.

Modified Otter Trawl Groundgear to Reduce the Catch of Juvenile American Plaice (Sally Roman)

A commercially used fishing technology referred to as a riser groundgear was modified with escape windows in an attempt to reduce the discards of sublegal American plaice (*Hippoglossoides platessoides*) in the large mesh otter trawl groundfish fishery on Georges Bank. Discard reduction of other sublegal species, witch flounder (*Glyptocephalus cynoglossus*) and monkfish (*Lophius americanus*), typically caught with American plaice was a secondary goal. The modified riser groundgear was tested using alternating tows in comparative fishing sea trials over two seven day fishing trips in March of 2011. The escape window dimensions were 41 cm by 25 cm on the first trip and 20 cm by 25 cm for the second trip. Catch results indicated a significant reduction in the catch of sublegal American plaice, witch flounder, and monkfish along with a significant reduction in the catch of legal sized American plaice. Generalized linear mixed models were employed to model the relative efficiency of the experimental gear for five target species (American plaice, witch flounder, monkfish, Atlantic cod (*Gadus morhua*), and haddock (*Melanogrammus aeglefinus*)). Modelling results indicated the experimental gear in either configuration had a lower relative efficiency compared to the control gear except for haddock. The experimental riser groundgear would need significant modifications before use in the commercial groundfish fishery in the region

Fish Behaviour and Conservation Engineering

Contact: phe@umassd.edu.

Bycatch reduction in northern shrimp trawls

An experiment replacing regular wire bridles with synthetic bridles has been completed. The use of "floating" polypropylene bridles kept the bridle off the seabed thus reducing herding of bottom-dwelling flatfish. A 20% reduction has been observed for important flounder species without a reduction in northern shrimp catch.

Species separation in groundfish trawls

A project testing the rope separator haddock on offshore grounds (Georges Bank) with a larger vessel >80 feet) was completed in May 2012. This trawl is a larger version of the rope separator trawl tested in inshore Gulf of Maine in 2006 when very positive results in reducing cod and flounders were realized in the new haddock trawl. The offshore trials resulted in reduction of flounder catch by 95%, skates catch by 84%, and cod catch by 87%. Haddock catch was reduced by 17%, but was not statistically significant after 24 pairs of tows. Another project (collaborating with Mass. Div. Mar. Fish.) to further understand behaviour of flounders and haddock, and to reduce flounder catch when targeting haddock was completed with sea trials concentrated on underwater filming of fish near bridles. The project intended to implement floating bridles in haddock trawls to reduce bottom-dwelling flatfish. Video and data are being analysed.

Testing of a modified otter trawl groundgear to reduce the catch of juvenile cod and yellowtail flounder

A modified Rubber Riser groundgear with escape windows will be tested on the Georges Bank large mesh fishery to reduce yellowtail flounder while targeting cod and haddock. Sea trials will be carried out in May 2013.

Test of a modified groundfish trawl to reduce the catch of Southern New England winter flounder

A modified Rubber Riser groundgear with escape windows is being tested off Rhode Island to reduce winter flounder while targeting Atlantic cod. The first leg of sea trials has been completed in March/April this year, with remaining sea trials to be completed in October/November 2013.

Silver hake trawl research

Small mesh silver hake trawls may catch other groundfish and spiny dogfish, as well as other controlled species. One silver hake trawl design incorporating large meshes in the front end of the trawl to reduce spiny dogfish is being tested in Southern New

England waters. Another silver hake trawl incorporating belly large mesh windows to reduce flounders in Gulf of Maine has just been completed.

Squid trawl bycatch reduction (collaborating with Mass. Div. Mar. Fish.)

Squid trawls in southern New England also catch other species such as butterfish, black sea bass, scup, and winter flounder. To reduce these species, a grid was designed and tested in flume tank. Sea trials with the new grid started in May 2011, and completed in June 2012. Video recording from 2011 and 2012 trials are being analysed. A paper documenting behaviour of squid at sorting grid has just been published in Fisheries Research.

Redfish codend selectivity (collaborating with Mass. Div. Mar. Fish.)

We have started a redfish codend trawl selectivity project. The project compares selectivity properties of three codends: 4.5-inch, 5.5-inch, and 6.5-inch diamond mesh sizes on board a commercial fishing vessel using the trouser-trawl method. Sea trials have completed with data analysis continuing.

Elasmobranchs electro-magneto-reception and their conservation

Craig O'Connell, a PhD candidate in the group, is carrying out several projects investigating electro-magneto-reception of elasmobranchs and its application in hook and line fisheries to reduce bycatch of spiny dogfish and in beach nets to reduce mortality of large predatory sharks. Three papers have recently been published in Coastal and Ocean Management.

Scallop dredge

A new project has started to re-design the New Bedford-style scallop dredge to reduce yellowtail flounder bycatch and to reduce fuel costs and seabed impact during dredging. Sea trials have started and will be continuing in spring/summer 2013.

GEARNET

SMAST is part of the GEARNET project with more than a dozen projects ranging from bycatch reduction, fuel saving, to mitigating seabed impact of fishing operations.

12.13.5 Gulf of Maine Research Institute (GMRI), Portland, Maine

Steve Eayrs (steve@gmri.org)

Energy audits for fishermen

In 2012, we arranged for energy audits to be conducted on four fishing boats in the New England groundfish fleet. The audit was an extensive process, requiring an initial interview with the captain to better understand boat handling and operating practices, followed by detailed inspection and measurement of key boat features including vessel spaces, all machinery and propulsion systems, and refrigeration and wheelhouse equipment. The completed audit permitted identification of a suite of potential modifications to conserve fuel, ranging from reduced stabilizer use to extending boat length. The cost of these modifications, their associated fuel saving and payback period was estimated and provided to each fisherman. We showed how a fisherman spending \$30 000 on fuel per year could reduce this expense by 26% if he spend \$5 500 on fuel saving options with a payback period of less than one year.

This work was funded by the National Fish and Wildlife Foundation.

Semi pelagic door finance model

Recognizing that fishermen are struggling to adopt highly efficient, semi-pelagic doors (otter boards) to reduce fuel consumption, we partnered with Coastal Enterprises Inc. to provide low interest finance to fishermen with flexible repayments capped at a level not exceeding 10% of their annual fuel cost. This cap was selected because in a previous study we found these doors reduced fuel consumption by 12%. Additionally we found these doors substantially reduced seabed impact with 95% of the door shoe clear of the seabed and there was no loss of commercial catch.

By capping repayments to this level fishermen are in effect directing up to 10% of their annual fuel expense to repay their loan, and in doing so the payback period is usually no more than 18 months and maybe as little as 4 months on larger boats. We attempted to make this offer even more attractive by offering a $2,000 rebate to any fisherman that purchased and installed these doors. This rebate was provided by the Alex C. Walker Foundation and GEARNET, a multidisciplinary project spearheaded by GMRI and MASS DMF, and funded by NOAA's Northeast Fisheries Science Center Northeast Cooperative Research Program (NEFSC NCRP). We also encouraged the purchase of a fuel meter because these are a relatively inexpensive yet highly effective fuel saving option.

Following an initial flurry of interest late last year, only two fishermen have since moved forward and taken up this opportunity. The remainder has held off primarily because of a proposed 77% reduction in cod allocation commencing in May, 2013. We are in the process of developing a data collection program so that both fishermen can record fuel consumption data at selected intervals during a tow, in a comparative study between traditional bottom tending doors and the new semi-pelagic doors. These two fishermen, and the handful that already use these doors, are glowing in their report about these doors, with all enjoying substantial fuel savings and no discernible loss of catch, and at least one fishermen is claiming fuel savings of close to 20%. This option has just been re advertised and we are hopeful of attracting additional fishermen to adopt these doors.

GEARNET – The Northeast Groundfish Gear Conservation Engineering and Demonstration Network

GEARNET was established in September 2010 to help Northeast groundfish fishermen develop and adopt fishing equipment that improves their efficiency and selectivity, reduces environmental impact, and helps secure a sustainable, profitable groundfish resource and industry for future years. This year GEARNET is supporting 18 small-scale research projects to address the immediate needs of fishermen and in many instances, simultaneously improve efficiency and reduce the negative environmental outputs of fishing such as discards and seabed impact. These projects have only just commenced and include funding two initiatives by fishermen to test the impact of raised ground cables (sweeps) of trawl performance, seabed impact, and fuel consumption. These cables are raised using bobbins measuring 200 cm or 250 cm in diameter. GEARNET is making semi-pelagic trawl doors available for testing by interested fishermen at no cost, is providing fishermen with low-drag netting to install and reduce fuel consumption, and has funded the purchase of cod pots and electronic jigging machines. Steps are also being taken to support fishermen to retest raised footrope gillnets to reduce catches of cod while maintaining catches of Pollock or white hake. These gillnets are raised either 60 cm, 120 cm or 180 cm using panels of 300 cm monofilament netting. Testing of these gillnets last year was inconclusive, primarily due to low catch rates, and the fishermen are interested in participating a repeat, albeit extended, testing program. GEARNET is a unique partnership in the region spearheaded several researchers, extension specialists, a netmaker and a fisherman and NOAA staff, and is funded by NOAA Fisheries Science Center Northeast Cooperative Research Program.

Are codend catch sensors a practical operational tool for sector quota management?

In partnership with the Northeast Seafood Coalition based in Gloucester, MA, we showcased acoustic codend catch sensors to groundfish fishermen and provide them an opportunity to briefly incorporate their use into their day to day fishing operation. We showcased three types of catch sensor, one each from Northstar, Simrad, and Notus, and tested them across multiple boats and locations in the fishery. We also asked fishermen to complete a questionnaire regarding their experiences and perceptions of sensor use and operation.

Almost universally fishermen were very satisfied about sensor performance and associated benefits, although we noted that performance was influenced by catch volume and composition. For example, the sensors often underestimated catches of pollock *Pollachius virens* and we presume this was because many were swimming within the confines of the net when the sensor was triggered. Many cited an ability to regulate catch volume as key to the uptake of these sensors, particularly to avoid large catches of dogfish or to help regulate landings of species for which fishermen have limited allocation. Shorter tows were also cited as a benefit of their use including associated reduction in fuel consumption. In some instances tow duration was reduced by as much as 50% on the strength of information gleaned from this sensor.

Sensor uptake by fishermen is low at present in part because sensor cost is high. We explored payback periods based on presumed catch savings and estimate that for large boats at least these payback periods could be as short as a few months. This project was funded NOAA's Northeast Fisheries Science Center Northeast Cooperative Research Program.

Introduction of electronic vessel trip reports (eVTRs)

The purpose of this project is to test the feasibility of adopting electronic solutions for vessel reporting requirements across a range of vessels in the northeast groundfish fleet. This includes testing a range of electronic logbook products in conjunction with the NMFS' web-based data entry system to identify obstacles in their use and to ensure their compatibility with NMFS' data collection systems.

Following the 2011-2012 fishing year, in which 13 vessels were equipped with the training and equipment to report VTRs electronically (and of which only 4 were actually using it to report) we have now expanded to having a total of 32 vessels equipped, of which 23 are actively using it and have transmitted over 500 trip reports. While each captain generally has some initial complaints or concerns about the system, for the most part every active user is very happy with sending their reports electronically after a brief period to gain system familiarity. We work closely with the captains, their sector managers, and NOAA to ensure a smooth transition to electronic reporting. The benefits of electronic reporting include quicker and less error prone transmission of VTRs, which enables fishermen to focus on their fishing operation, allows sector managers to receive data are a more useful format and reduces their data entry burden, and allows NOAA to receive timely information regarding catch and effort data. This project is funded NOAA's Northeast Fisheries Science Center and the Northeast Regional Office.

12.13.6 Oregon Department of Fish and Wildlife, Marine Resources Program, Newport, Oregon

Bob Hannah (bob.w.hannah@state.or.us), Steve Jones, Polly Rankin, Matthew Blume

Evaluating the effect of "footrope windows" on demersal fish bycatch in an ocean shrimp trawl

This experiment continues work started in 2011 aimed at developing shrimp trawl footropes that reduce the entrainment of small demersal fish, including eulachon (theatened status), while maintaining shrimp catch rates. In 2012, we removed a roughly 2 m section from the central portion of the trawl groundline. Results were promising, but inconclusive statistically for eulachon due to a single aberrant large catch of eulachon in the treatment net. Without this haul, eulachon reduction was 18.5% with 6.6% shrimp loss.

Estimating discard mortality of rockfish with barotrauma

Field studies to generate cage-based estimates of discard mortality (post-recompression) of Pacific rockfish in the recreational hook and line fishery (primarily canary and yelloweye rockfish) were expanded out to greater depths(60-120 m) and slightly longer holding periods. Yelloweye rockfish continued to show high survival rates.

Development and testing of a stereo video lander for assessment of deep-water rocky reef fish populations

A stereo, high-definition version of the video lander was developed and field-tested to facilitate survey work on deep water high-relief rocky reefs.

Future Work:

- Additional field tests of "footrope windows" in ocean shrimp trawls will be conducted.
- Cage-based estimates of discard mortality (post-recompression) of Pacific rockfishes in the recreational hook and line fishery - canary and yelloweye rockfish will be continued at greater depths(60-120 m).
- Field tests of a newly developed stereo video lander for deep water high-relief rocky reefs will be continued and include an assessment of the effect of bait on the fish counts and size range of fish seen.
- A re-survey of the mud habitats around Nehalem Bank with ROV is planned for 2013 to evaluate changes in benthic macroinvertebrate populations 6 years after some of the sites were closed to all trawling.

13 Other Business

13.1 Date and Venue for 2014 WGFTFB Meeting

The **ICES/FAO Working Group on Fishing Technology and Fish Behaviour** [WGFTFB] (Chairs: Michael Pol, USA; Petri Suuronen, FAO) will meet in New Bedford, Massachusetts, USA from 5-9 May 2014, at the invitation of the National Marine Fisheries Service, University of Massachusetts-Dartmouth School for Marine Science and Technology, and the Massachusetts Division of Marine Fisheries. The meeting will include a joint session (Monday 5 May, 2014) with the Working Group on Fisheries Acoustics and Fishing Technology.

13.2 Selection of ICES Chair

The current ICES Chair informed the group during the intersessional period of the opportunity to nominate or identify potential candidates for the incoming ICES WGFTFB Chair to serve from January 2014 until December 2016. Nominations were also solicited during the meeting. At the request of the ICES Chair, candidates were asked to have a WG member speak from the floor to identify the candidate and his/her qualifications. Paul Winger of Canada nominated and endorsed **Pingguo He** of USA to be the next Chair; his nomination was approved by unanimous acclimation; his name will be forwarded to SCICOM for consideration.

13.3 Proposals for 2014 ASC Theme Sessions

Following another round of unsuccessful proposals for theme sessions, the ICES chair was asked to investigate how to improve proposals from WGFTFB. The Chair shared these points after speaking with SCICOM members and other sources:

- The overall feedback is that the competition is very strong. More proposals than ever, more sessions than ever.
- To be successful, build support for the proposal; communicate with National SCICOM members for theme session concepts
- Work with other EG chairs to develop shared proposals e.g. bycatch, broader ecosystem impact of fishing
- Avoid overlap with other proposals
- Work closely with ACOM and obtain support.
- Link as strongly as possible to the Science Plan
- Consider how broad the appeal of the session would be (appealing only to one WG is not adequate)
- Focus needs to be clearly stated and conveyed
- Innovative sessions are more highly rated
- SCICOM is inclined toward more basic research than fishing technology

Two proposals were drafted at the meeting and endorsed by the group, one considering the impacts of catch quotas through the new Common Fisheries Policy, and one investigating barriers and incentives toward uptake.

13.3.1 Introducing catch limits– lesson learned and forward look

Proposed by T. Catchpole (UK)

The European Union's reform of the Common Fisheries Policy (CFP) is expected to bring about fundamental changes in commercial fishing operations. Under the current CFP it is illegal to land catches that did not comply/conform with prescribed catch compositions, legal landing sizes (so-called MLS) or Total Allowable Catches (TACs). These components of catch, and catch with low or no market value, were thrown back (discarded) to the sea and most of these fish did not survive being caught. In recognition of the negative economic and ecological consequences of discarding, and the growing public belief that the practice is socially unacceptable, the elimination of discards in European fisheries is a specific objective of the new CFP.

An alternative approach is the adoption of catch quotas rather than landings quotas, with an obligation to land all catches. The principle of which is to limit total catch for a single or group of species and when a catch quota in a fishery is met, fishing activities cease. To maximize the revenue from allocated catch quota, fishermen are incentivised to avoid catching fish that would otherwise result a curtailment of the fishing season and to avoid catching undersized, juvenile, low value fish, which would be deducted from their quota for little or no profit.

Catch limits have been introduced in several other countries (e.g. Alaska, USA, Iceland and New Zealand). Experiences from these areas can inform on the likely changes to transpire in European fisheries and demonstrate best practice. This session will focus on the concept of a move to catch limits in fisheries management and presentations covering the following issues are welcome:

- Incentivising behaviour change in fishing activities with catch limits
- Managing catch limits in mixed fisheries
- Changes in the biodiversity and size range of catches
- Ecological impacts of catch limits and a landing obligation
- Social and economic consequences of a change to catch limits and a land-all policy
- Fisheries data collection under a regime of catch limits and a landing obligation
- Logistical issues in landing previously unwanted catches
- Monitoring and enforcement of catch limits and a discard ban
- Changing fishing mortality in unwanted or vulnerable previously discard fish

13.3.2 Proposal: Why are fishermen reluctant to use new gear?

Proposed by S. Eayrs (USA)

Substantial investment of time and effort by fishing technologists, fishermen, and others has produced useful results in bycatch reduction and species separation through fishing gear modification. Even where these modifications represent positive changes that reduce environmental impact and increase profitability, reluctance by fishermen to uptake these modifications is usually high. In most fisheries the need to change is ever-increasing due primarily to the increased effects of climate alteration on stock abundance, fuel price instability, food insecurity, and need for clearly demonstrated sustainable fisheries development. The need to change fishing practice or gear is therefore clear and present, and often identified by fishermen themselves; nevertheless, their uptake of gear innovation is low.

We propose to bring together expertise in fishing technology, fisheries management, human behavior, and outreach to examine cases of both successful and unsuccessful uptake and change, recognized principles of change management (including prospect theory) and their application to fisheries, and how to optimize uptake. As an outcome, we expect to identify, describe and summarize opportunities and circumstances under various fishing conditions that increase the likelihood of uptake and change by fishermen.

13.4 Joint Session

The Joint Session of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour [WGFTFB] and the Working Group on Fisheries Acoustics Science and Technology [WGFAST] – [JFATB] (Co-Chairs: Paul Winger (Memorial University, Canada) and Kresimir Williams (NOAA-AFSC, USA) will meet in New Bedford, Massachusetts, USA, Monday 5 May, 2014.

This one-day workshop will focus on:

a) Emerging acoustic and optical technologies, including significant field leading advances in technology, procedures and protocols. Application may include the study of fish behaviour, abundance estimation, and impacts of fishing gear on the ecosystem. Small updates to existing systems or the transfer of existing systems to new fisheries may also be considered, if space permits.

b) issues in trawl-surveys, including factors known to bias estimates of population abundance and size-composition, survey trawl standardization, estimates of effective swept-area, etc.

JFATB will report by June 30, 2014 for the attention of the SCICOMM Committee.

13.5 Topic Group Terms of Reference for 2014 for WGFTFB

13.5.1 Artificial light in fishing gear

A WGFTFB topic group of experts formed in 2012 will meet in 2014 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions.

Specifically the group aims to:

- Describe and summarize fish response to artificial light stimuli;
- Describe and summarize use of artificial light in world fisheries;
- Describe and tabulate different light sources to attract fish;
- Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions; and
- Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods.”

- Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture

13.5.2 Dynamic Catch Controls

A WGFTFB topic group of experts formed in 2013 will continue in 2014 to investigate innovative dynamic catch control devices in fishing. Dynamic catch control systems are defined as catch control systems that change the structure and functioning of the gear during the fishing operation so that the gear stops collecting fish when desired amount of fish has entered the retention part of the gear, or actively releases excessive fish with least level of mortality. The group will have the following terms of reference:

i) Review the fisheries, conditions, and impact on mortality where dynamic catch control can be an advantage and consider/share recent improvements towards commercial fisheries.

ii) Provide improvements/solutions for the challenges related to excessive catches that are encountered in the different fisheries and gears worldwide.

iii) Produce a report including a review of the status of knowledge and technology on the subject, with identification of technology gaps, and recommendations for future research on the technology for the different fisheries and fishing gears.

13.5.3 Relationships among vessel characteristics and gear specifications in commercial fisheries

Following the proposal of Antonello Sala (Italy) to form a WGFTFB topic group of experts in 2012 to investigate relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries, the topic group formed in 2013 will continue in 2014 to investigate such relationships with the following terms of reference:

i) review technical specifications of trawl gears used in different fisheries (benthic, demersal and pelagic) with attention, in particular, to the dimensions of headline, footrope, circumference or perimeter at various levels of the net, extension piece, codend, otterboard, and other aspects;

ii) model and describe relations between engine power and gear-size characteristics of European trawl fleets. Modelling engine power and different parts of the fishing gears as well as between some of these parts and the otter-board size should be investigated.

13.5.4 Technological Innovation in Spreading Trawls

A WGFTFB topic group of experts, convened by Paul Winger (Canada), Bob van Marlen (Netherlands), Antonello Sala (Italy), will be formed in 2014 to document and evaluate recent technological advancements in spreading technology for mobile trawls. The terms of reference will include:

1) Describe and summarize new and innovative technological advancements under development (or recently developed) for spreading mobile trawls.

2) Review technical challenges and obstacles for uptake by industry.

3) Identify new applications for these technologies and opportunities for technology transfer.

Justification:

Mobile bottom trawls are known to produce ecological impacts in many fisheries (He and Winger, 2010; Lucchetti and Sala, 2012). The devices used to spread these trawls (typically doors) contribute heavily to fuel consumption and seabed impacts. In response to these concerns, several countries have initiated research projects in recent years toward the development of creative and innovative approaches to spreading mobile trawls. Moving beyond basic doors and beams, new research efforts are now breaking ground toward off-bottom doors, maneuverable or steerable doors, kites, and hydrodynamic beam concepts. A synthesis of these technological advancements will provide up-to-date information, stimulating innovation and opportunities for technology transfer.

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Annex 2: Agenda

6 May 2013 (Monday)

08:00 – 09:00	Registration
09:00 – 09:30	Welcome and General Introduction of the Meeting ***(Bundit Chokesanguan)*** Speech and Opening from Secretary-General of SEAFDEC ***(Chumnarn Pongsri)*** Speech and Opening from FAO ***(TBA)*** Greetings, Introductions, and Transition to LIFE Session ***(Michael Pol and Petri Suuronen)***

"LIFE" Mini-Symposium

Opening Addresses, Welcome and Meeting Housekeeping

09:30 – 09:45	Introduction, Welcome ***(Thomas Catchpole)***
09:45 - 10:15	Keynote – "Low-Impact and Fuel-Efficient (LIFE) Fishing Challenges, Opportunities and Some Technical Solutions" ***(John Willy Valdemarsen, Petri Suuronen)***
10:15 – 10:40	***Body and Mind Break (Coffee and Tea)***

Mobile Gear Fishing

10:40 - 11:00	Propulsion System Optimizations for Fuel Saving in Trawlers ***(Emilio Notti, Antonello Sala)***
11:00 - 11:20	A Comparison of the Fishing Gear Efficiency on the Trawl with Knotted and Knot-less Net Webbings ***(Shigeru Fuwa, Saeko Kude, Keigo Ebata, Hiroyasu Mizoguchi)***
11:20 - 11:40	The Development of Pulse Trawling in the Netherlands ***(Bob van Marlen)***
11:40 - 12:00	Reduction of Hydrodynamic Force Acting on Bottom-trawlnet ***(Keigo Ebata, Shinpei Teraji)***

12:00 – 13:00	***Lunch***
13:00 - 13:20	Using Best Available Technology Drastically Improve Fuel Efficiency in Trawl Fisheries ***(Ulrik J Hansen, Johan W Nielsen, Jacob L Rønfeldt)***
13:20 - 13:40	CIFT's Initiatives Towards Development of Green Fishing Systems for Indian Waters ***(Leela Edwin, T.K. Srinivasa Gopal)***

Stationary Gear Fishing

13:40 - 14:00	A Comparison of Two Catch Rate Calculation Methods: Application to a Longline Tuna Fishery ***(Liming Song, Weiyun Xu, Daomei Cao, Jie Li)***
14:00 - 14:20	Comparative Baited Pots Trials to Harvest Northern Stone Crab (*Lithodes maja*) and White Hake (*Urophycis tenuis*) ***(Philip Walsh Rennie Sullivan)***
14:20 – 14:50	***Body and Mind Break (Coffee and Tea)***
14:50 - 15:10	Operation System Analysis of Set-net in Rayong Thailand from the View Point of Cost-profit Simulation with Fuel Consumption Assessment ***(T. Arimoto, T. Kudoh, Y. Takashima, K. Ebata, A. Boutson, A. Munprasit, T. Amornpiyakurit, N. Manajit, W. Yingyuad, Yap Minlee, S. Ishikawa)***
15:10 - 15:30	Seasonal Variation in Fishing Operations and Fuel Consumption of Small Scale Fisheries in Rayong, Thailand ***(Keigo Ebata, Anukorn Boutson, Isara Chanrachkit, Nakaret Yasook, Tanut Srikum, Takafumi Arimoto, Takatsugu Kudoh, Minlee Yap, Satoshi Ishikawa)***

Tools for LIFE fishing

15:30 - 15:50	Energy Saving Fishing Gears Design Using a Numerical Simulation ***(Chun-Woo Lee, Jihoon Lee)***
15:50 - 16:10	GEARNET: A Bottom–up Approach to Gear Testing and Uptake ***(Michael Pol, Steve Eayrs, Pingguo He)***

16:10 – 16:30	Developing Fishing Gear to Reduce Environmental Impact and Increase the Profitability of Fishermen in the New England Groundfish fishery: So Why are They so Reluctant to Use This New Gear? ***(Steve Eayrs, Christopher Glass)***
16:30 – 17:10	Discussion, Conclusions and Recommendations and Closing
17:30 – 20:00	***Welcoming Reception***

7 May 2013 (Tuesday)

"LIGHT" Mini-Symposium

Introduction

09:00 – 09:20	An Introduction to Light and its Measurement When Investigating Fish Behaviour ***(Mike Breen)***
09:20 – 09:50	Keynote – "Fish Behaviour and Visual Physiology in Capture Process of Light Fishing" ***(T. Arimoto)***

Physics and Engineering

09:50 – 10:10	Marine Optics - Essential Elements for Fishing Technology and Fish Behaviour ***(Yoshiki Matsushita)***
10:10 - 10:30	Review of Technological Design: LED Packaging and Lighting ***(Ja Soon Jang)***
10:30 – 11:00	***Body and Mind Break (Coffee and Tea)***
11:00 – 11:20	Research on Artificial Light Sources for Light Fishing ***(Heui Chun An)***
11:20 - 11:40	Light Output Arrangement in Light Fishing through the Use of Simulation Model of Underwater Illuminance Distribution ***(Sugeng Wisudo)***
11:40 - 12:00	Novel Power Supply Technologies for Artificial Lights on Fishing Gears / Energy Harvesting in the Trawling Environment ***(Dan Watson)***

12:00 – 13:00	***Lunch***

Biology and Behaviour

13:00 - 13:20	The Biology of Underwater Vision ***(Ronald Kröger)***
13:20 - 13:40	Polarization Vision in the Sea ***(Amit Lerner)***
13:40 - 14:00	Development of the Evaluation Method on the Effect of Artificial Fishing Light ***(Kazuhiko Anraku)***
14:00 - 14:20	Visual Threshold of Rockfish (*Sebastes inermis*) Response to Different Wavelength of LED Lamp ***(Hyeon-Ok Shin)***
14:20 – 14:50	***Body and Mind Break (Coffee and Tea)***
14:50 - 15:10	Attracting Effects on Swimming Behaviour Patterns of the Chub Mackerel (*Scomber japonicus*) and Common Squid (*Todarodes pacificus*) by LED Luring Lamp ***(Kyounghoon Lee)***

Light Fishing

15:10 - 15:30	Progress of Fish Luring Lamps for Squids Jigging in China ***(Weiguo Qian)***
15:30 - 15:50	Fishing Efficiency of LED Fishing Lamp for Squid Jigging and Hair Tail Angling in Korean Waters ***(Young-Il An***)
15:50 - 16:10	Application of the Low-power Underwater Light to a Large-scale Fish-trap Fishery ***(Daisaku Masuda)***
16:10 – 16:30	Modifying Baited Cod Pots to Capture Flatfish Species while Excluding Snow Crab ***(Andrew Murphy)***
16:30 – 17:30	Discussion, Conclusions and Recommendations

8 May 2013 (Wednesday)

"SHRIMP" Mini-Symposium

09:00 – 09:20	Introduction, Welcome ***(Pingguo He and Bundit Chokesanguan)***
09:20 – 10:05	Keynote- Understanding and Managing Impacts on Bycatch in Australia's Northern Prawn Fishery ***(David Brewer and Co-authors: S. Griffiths, S. Zhou, S. Eayrs, I. Stobutzkic, R. Bustamante and C. Dichmont, CSIRO Marine and Atmospheric Research, Australia)***

Chair: Pingguo He (USA)

10:05 – 10:30	Incorporating Human Dimension in the Bycatch Management of Shrimp/Bottom-trawl Fisheries ***(Petri Suuronen and Daniela Kalikoski, Fishing Operations and Technology Service, FAO)***
10:30 – 11:00	***Body and Mind Break (Coffee and Tea)***
11:00 - 11:20	Research on Bycatch of Shrimp Trawl Fishery in Arafuru Sea: Volume, Reduction Devices, and Utilization of Discarded Bycatch ***(Ari Purbayanto, Ronny I. Wahyu, and Joko Santoso, Bogor AgriculturalUniversity, Indonesia)***
11:20 - 11:40	Selectivity of Five Different Codend Designs to Improve Size Selectivity for Deep Water Rose Shrimp (*Parapenaeus longirostris*) in the Aegean Sea ***(Adna Tokaç, Hưseyin Özbilgin and Hakan Kaykaç, Ege University, Turkey)***
11:40 – 12:00	Discard Ratios of Fish and Shrimp Trawls in the Northeastern Mediterranean ***(Gökhan Gökçe, Ahmet Eryaşar, Yeliz Özbilgin, Adem Bozaoğlu, Ebrucan Kalecik and Hüseyin Özbilgin, Cukurova University, Turkey)***
12:00 – 13:00	***Lunch***

Chair: Bundit Chokesanguan (Thailand)

13:00 - 13:20	A Decade of Systematic Research to Minimize Discards in Northern Shrimp Trawls ***(Pingguo He, University of Massachusetts Dartmouth School for Marine Science and Technology, USA)***

13:20 - 13:40	When Shrimp Trawling Collides with Crab Fisheries: A Case Study from Newfoundland, Canada. ***(Truong Nguyen, Paul Winger, George Legge, Earl Dawe and Darrell Mullowney, Memorial University of Newfoundland, Canada)***
13:40 - 14:00	Trawling for Shrimps and Simultaneously Retaining Cod ***(Eduardo Gramaldo, Jørgen Vollstad and Roger B. Larsen, SINTEF Fisheries and Aquaculture, Norway)***
14:00 - 14:20	The Promotion of Responsible Trawl Fishing Practices in Southeast Asia through the Introduction of Juvenile and Trash Excluder Devices (JTEDs) ***(Suppachai Ananpongsuk, SEAFDEC)***
14:20 – 14:50	***Body and Mind Break (Coffee and Tea)***
14:50 - 15:10	Netting Grids in *Nephrops* Trawls to Reduce the Capture of Cod in the North Sea ***(FG O'Neill, RJ Kynoch, J Drewery, A Edridge, J Mair, Marine Scotland Science, Marine Laboratory, UK)***
15:10 - 15:30	Development of Sorting Grids for Norway Lobster Fisheries ***(Niels Madsen, Rikke Frandsen, Jordan Feekings, Ludvig A. Krag, DTU Aqua, Denmark)***
15:30 - 15:50	REBYC-II CTI Trawl Fisheries Management in Southeast Asia and Coral Triangle Region ***(Petri Suuronen (FAO), Isara Chanrachkij, SEAFDEC)***
15:50 - 16:10	Introducing a RIHN Project (Coastal Area Capability Enhancement in Southeast Asia) ***(Minlee Yap, RHIN)***
16:10 – 17:20	Discussion, Conclusions and Recommendations
17:20 – 17:30	***Closing***
17:30 – 20:00	***Social Event***

9 May 2013 (Thursday)

FTFB Open Session	
09:00 – 09:30	Housekeeping Issues, Welcome, Agenda Review
09:30 - 09:50	Understanding the Size Selectivity in Diamond Mesh Codends Based on Flume Tank Experiments and Fish Morphology: Effect of Catch Size and Fish Escape Behaviour ***(Junita Karlsen)***
09:50 - 10:10	Observation of Fish Behaviour During Demersal Trawling Operations in The Northeastern Mediterranean ***(Hüseyin Özbilgin)***
10:10 - 10:30	Can we save toothfish, killer whales and fishermen together? **(Gérard Bavouzet)**
10:30 – 11:00	***Body and Mind Break (Coffee and Tea)***
11:00 – 11:20	Swimming Performance of Fish in Capture Process Simulation Examined by EMG / ECG Monitoring and Muscle Twitch Experiment. ***(Mochammad Riyanto)***
11:20 – 11:40	Improvement of Size Selectivity and Short-term Commercial Loss in the Eastern Mediterranean Demersal Trawl Fishery ***(Hüseyin Özbilgin)***
11:40 – 12:00	Test of the Rope Separator Haddock Trawl on Georges Bank ***(Chris Rillihan)***
12:00 – 13:00	***Lunch***
13:00 - 13:20	FTFB Topic Group Introductions ***(Topic Group Conveners)***
13:20 – 15:00	Topic Group Meetings ***(3 Separate Meetings; Agenda at Discretion of Conveners)***
15:00 – 15:30	***Body and Mind Break (Coffee and Tea)***
15:30 – 17:00	Topic Group Meetings ***(Continue)***
17:00 – 17:10	Closing

10 May 2013 (Friday)

FTFB	
09:00 – 09:30	ICES Stuff and Summary of National Reports ***(Mr Michael Pol)***
09:30 – 10:00	ToR A CATCH CONTROL: Report, Conclusions and Recommendations ***(Conveners)***
10:00 – 10:30	ToR B LIGHT: Report, Conclusions and Recommendations ***(Conveners)***
10:30 – 11:00	***Body and Mind Break (Coffee and Tea)***
11:00 – 11:45	ToR C GEAR: Report, Conclusions and Recommendations ***(Conveners)***
11:45 – 12:00	ToRs for 2014 ***(Including Joint Session, and Appointment of Joint Session Chair)***
12:00 – 13:00	***Lunch***
13:00 – 13:45	ToRs for 2014 ***(Continued)***
13:45 – 14:30	Suggestions for ASC Theme Session Topics 2014; ICES Symposia
14:30 – 15:00	***Body and Mind Break (Coffee and Tea)***
15:00 – 15:15	Date and Venue for WGFTFB 2014 Meeting
15:15 - 15:45	Selection of New Chair
15:45 – 16:00	AOB and Concluding Remarks (Co-chairs)

Annex 3: WGFTFB multi-annual terms of reference for the next meeting

The ICES-FAO **Working Group on Fishing Technology and Fish Behaviour** (WGFTFB), chaired by Pingguo He*, USA, and Petri Suuronen, FAO, will meet in New Bedford, USA, 5–9 May 2014, to work on ToRs and generate deliverables as listed in the Table below.

WGFTFB will report on the activities of 2014 by 25 June 2014 to SSGESST.

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Present recent investigations into and synthesize current knowledge of topics related to: “Design, planning, and testing of fishing gears used in abundance estimation”; “Selective fishing gears for bycatch and discard reductions”; “Environmentally benign fishing gears and methods” and summary of research activities by nation	Through open sessions and focused, multiyear topic groups, the Working Group provides opportunities for collaboratively developing research proposals, producing reports and manuscripts, and creating techncial manuals on current developments and innovations.	21, 34, primarily; others are possible (e.g. 11,133, 223, 33, *et al.*)	3 Years	ICES report;
b	Organize an FAO hosted FAO-ICES mini-symposium with thematic issues as described in the Barange-Matthiesen exchange of letters	Under mutual agreement between ICES and FAO, FAO develops and leads a mini-symposium of relevant topics, while also continuing ICES commitments	21, 34	Year 3	FAO report, ICES report
c	Present recent investigations into topics of mutual interest between WGFTFB and WGFAST	Every third year, WGFAST and WGFTFB meet for one day to share information on topics of mutual interest (JFATB)	16, 21	Year 1	JFATB report
D	Every second year, describe changes in EU fishing fleets and effort relevant to assessment working groups	WGFTFB has produced this advice for several years and been encouraged to continue by Assessment WGs		Years 1, 3	Reports to individual EGs

e	Organize an ICES-sponsored international fishing technology Symposium	Organize the Third ICES Symposium of Fish Behaviour	Fall 2017 (outside scope of this Multiannual TOR)	Symposium and special issue in ICES Journal of Marine Science
F	Develop survey and gear expertise support for survey working groups via ASC and survey group meetings	SSGESST has identified gear expertise gaps in survey working groups.	Year 1,2	Identify WGFTFB members who can fulfill advisory roles ; Review survey protocols.

Summary of the Work Plan

Year 1	Produce the annual report; hold joint session with WGFAST; inform assessment EGs on fleet effort changes; connect to survey WGs
Year 2	Produce annual report; Continue development of relationships with survey EGs
Year 3	Produce the annual report; inform assessment EGs on fleet effort changes; organize FAO mini-symposium

“Supporting information

Priority	The activities of WGFTFB will provide ICES with knwledge and expertise on issues related to the ecosystem effects of fisheries, especially the evaluation and reduction of the impact of fishing on marine resources and ecosystems and the sustainable use of ecosystems and other topics related to the performance of fishing gears and survey gears.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 40–45 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	Linkages to advisory groups via reports on changes to fleets and fleet effort
Linkages to other committees or groups	There is a very close working relationship with all the groups of SSGESST, WGFAST, and the survey groups.
Linkages to other organizations	The WG is jointly sponsored with the FAO.

Annex 4: Terms of Reference for Joint Session with WGFAST

A Joint Session of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour [WGFTFB] and the Working Group on Fisheries Acoustics Science and Technology [WGFAST] – [JFATB], chaired by Paul Winger* (Memorial University, Canada) and Kresimir Williams* (NOAA-AFSC, USA) will meet in New Bedford, Massachusetts, USA, Monday 5 May, 2014.

This one day workshop will focus on:

a) Emerging acoustic and optical technologies, including significant field leading advances in technology, procedures and protocols. Application may include the study of fish behaviour, abundance estimation, and impacts of fishing gear on the ecosystem. Small updates to existing systems or the transfer of existing systems to new fisheries may also be considered, if space permits.

b) Catchability issues in trawl-surveys, including factors known to bias estimates of population abundance and size-composition, survey trawl standardization, estimates of effective swept-area, etc.

JFATB will report by 30 June 2014 for the attention of the SCICOMM Committee.

Supporting information

Priority	Every 3 years, WGFTFB and WGFAST meet at a common location and date to facilitate networking, knowledge transfer, and shared scientific discovery. On one day, both expert groups meet in plenary for a joint session (called JFATB) on topics of common interest. Consequently, these activities are considered to have a very high priority.
Scientific justification	**Term of Reference a):** While a handful of reviews exist on optical and acoustic technology (e.g. Graham *et al.*, 2004; Churnside *et al.*, 2012), the pace of technological advancement is exceptionaly rapid. This session will provide an opportunity to disseminate latest developments in these emerging technologies, specifically as they apply to the study of fish behaviour, abundance estimation, trawl catchability, and impacts of fishing. **Term of Reference b):** Bottom-trawl surveys are an indispensable methodology for assessing the abundance of many fish stocks, and provides important information for the assessments. However, changes in “survey condition” or catchability, including coverage, fish behaviour, and degree of trawl standardization are known to introduce bias in abundance estimates, resulting in less accurate population indices and stock assessments. Many of these issues remain unresolved. This session will provide an opportunity to disseminate latest research and discuss emerging issues.
Resource requirements	No additional resources are required.
Participants	The workshop is normally attended by approximately 75-150 members and guests.
Secretariat facilities	None.
Financial	No financial implications.

Linkages to advisory committees	JFATB addresses challenges in acoustic and trawl surveys and has relevence to survey indices used in ICES advice. It is relevant to all Assessment Survey Groups.
Linkages to other committees or groups	JFATB is a collaboration between WGFAST and WGFTFB to promote cooperation and information transfer among the groups. It is also relevant to the Working Group on Ecosystem Effects of Fisheries
Linkages to other organizations	The work of this group is closely aligned with similar work in FAO; WGFTFB is jointly sponsored by ICES and FAO.

References:

Churnside, J., Jech, M., and Tenningen, E. (Eds). 2012. Fishery applications of optical technologies. ICES Cooperative Research Report No. 312. 91 pp.

Graham, N., Jones, E. G., and Reid, D. G. 2004. Review of *technological* advances for the study of fish behaviour in relation to demersal *fishing* trawls. ICES J. Mar. Sci., 61: 1036–1043.